

7. High-Silicon-Iron, Hub-and-Plain-End Pipe and Fittings: ASTM A 861, pipe and drainage-pattern fittings; acid-resistant packing; and lead calking materials.
  8. High-Silicon-Iron, Mechanical-Joint Pipe and Fittings: ASTM A 861, pipe and drainage-pattern fittings; and stainless-steel clamps with TFE inner sleeve and CR outer sleeve.
  9. Stainless-Steel Drainage Pipe and Fittings: ASME A112.3.1, ASTM A 666, Type 316L, stainless-steel pipe and drainage-pattern fittings; with socket and spigot ends for gasket joints; and having piping manufacturer's FPM lip-seal rubber gaskets shaped to fit socket groove, with plastic backup ring.
  10. Borosilicate Glass Pipe and Fittings: ASTM C 1053, pipe and drainage-pattern fittings; with manufacturer's standard couplings.
    - a. Covering: Factory-applied polystyrene for pipe installed underground.
  11. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.
- B. Double-Containment Pipe And Fittings
1. Description: Factory-fabricated, double-wall pipe and fittings. Sizes indicate carrier-pipe size; with carrier (inner) pipe and fittings; annular-space, carrier-pipe supports; containment (outer) pipe and fittings; and joining materials and fasteners. Include manufacturer's standard piping materials according to the following:
    - a. PE, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 4976, PE resin.
      - 1) Carrier and Containment Pipes: ASTM F 1412, Schedule 40.
      - 2) Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311.
    - b. PP, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 4101, PP resin.
      - 1) Carrier and Containment Pipes: ASTM F 1412, Schedule 40.
      - 2) Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311.
    - c. PP/PVC, Double-Containment Drainage Pipe and Fittings:
      - 1) PP Carrier Pipe: ASTM F 1412, Schedule 40; made of ASTM D 4101, PP resin.
      - 2) PP Carrier-Pipe Fittings: ASTM F 1412, Schedule 40 drainage pattern complying with ASTM D 3311; made of ASTM D 4101, PP resin.
      - 3) PVC Containment Pipe: ASTM D 2665, PVC pipe.
      - 4) PVC Containment Pipe Fittings: ASTM D 2665, PVC drainage pattern.
    - d. PVDF, Double-Containment Drainage Pipe and Fittings: Made of ASTM D 3222, PVDF resin.
      - 1) Carrier and Containment Pipes: ASTM F 1673, Schedule 40.
      - 2) Fittings: ASTM F 1673, Schedule 40 drainage pattern complying with ASTM D 3311.
    - e. PVDF/PVC, Double-Containment Drainage Pipe and Fittings:
      - 1) PVDF Carrier Pipe: ASTM F 1673, Schedule 40; made of ASTM D 3222, PVDF resin.
      - 2) PVDF Carrier-Pipe Fittings: ASTM F 1673, Schedule 40 drainage pattern complying with ASTM D 3311; made of ASTM D 3222, PVDF resin.
      - 3) PVC Containment Pipe: ASTM D 2665, PVC pipe.
      - 4) PVC Containment Pipe Fittings: ASTM D 2665, PVC drainage pattern.
  2. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.
- C. Field-Fabrication Containment Piping
1. Description: Containment split pipe and split fittings with carrier-pipe centralizers. Include manufacturer's fastening devices and materials.
    - a. Material: HDPE **OR** PP **OR** Yellow PVC **OR** Clear PVC, **as directed**, pipe and fittings.
    - b. Fastening System: FPM gaskets, clamps, and pins.



- c. Material: Clear PVC pipe and fittings with adhesive channels, for use with drainage-pattern carrier piping.
  - d. Fastening System: Adhesive.
- D. Joining Materials
  - 1. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.
  - 2. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.
  - 3. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.
  - 4. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
    - a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 5. Fiberglass-Pipe Adhesive: As furnished or recommended by pipe manufacturer.
    - a. Use fiberglass adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- E. Piping Specialties
  - 1. Plastic Dilution Traps:
    - a. Material: Corrosion-resistant PP, with removable base.
    - b. End Connections: Mechanical joint.
    - c. Dilution Tanks: 1-gal. (3.8-L) capacity, with clear base unless colored base is indicated; with two NPS 1-1/2 (DN 40) top inlets and one NPS 1-1/2 (DN 40) side outlet.
    - d. Small Dilution Jars: 1-pint (0.5-L) capacity, with clear base unless colored base is indicated; with NPS 1-1/2 (DN 40) top inlet and NPS 1-1/2 (DN 40) side outlet.
    - e. Large Dilution Jars: 1-quart (1-L) capacity; with NPS 1-1/2 (DN 40) top inlet and NPS 1-1/2 (DN 40) side outlet.
  - 2. High-Silicon-Iron Dilution Traps:
    - a. Standard: ASTM A 861.
    - b. Size: NPS 1-1/2 or NPS 2 (DN 40 or DN 50) as required for fixture and waste.
    - c. End Connections: Mechanical.
  - 3. Glass, Drain-Line, Interceptor Traps:
    - a. Standard: ASTM C 1053.
    - b. Type: Drum trap.
    - c. Size: NPS 1-1/2 (DN 40), NPS 2 by NPS 1-1/2 (DN 50 by DN 40), or NPS 2 (DN 50), as required to match connecting piping.
  - 4. Corrosion-Resistant Traps:
    - a. Type: P-trap or drum trap.
    - b. Size: NPS 1-1/2 or NPS 2 (DN 40 or DN 50), as required to match connected piping.
    - c. High-Silicon Iron: ASTM A 861, with horizontal outlet and hub-and-plain or plain ends to match connecting piping.
    - d. PP: ASTM D 4101, with mechanical-joint pipe connections.
    - e. PVDF: ASTM D 3222, with mechanical-joint pipe connections.
    - f. Glass: ASTM C 1053, with coupling pipe connections.
  - 5. High-Silicon-Iron Floor Drains:
    - a. Standard: ASTM A 861.
    - b. Body: With integral flashing flange and weep holes; and with flashing ring and stainless-steel strip, sediment basin and funnel attachment, **as directed**.

- c. Top: 8-3/4-inch (222-mm) diameter with grate.
    - d. Size: NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150) outlet as indicated.
  6. Stainless-Steel Floor Drains:
    - a. Standard: ASME A112.3.1, ASTM A 666, Type 316L.
    - b. Body: With 8.5-by-8.5-inch (215-by-215-mm) OR 12.4-by-12.4-inch (315-by-315-mm), **as directed**, top with grate.
    - c. Outlet: Bottom, of size indicated.
  7. PP Floor Drains:
    - a. Body: With 7- to 9-inch (178- to 230-mm) top diameter, with flashing flange and weep holes; and with flashing clamp, basket strainer, funnel attachment, and trap-primer connection, **as directed**.
    - b. Outlet: Bottom, to match connecting pipe, with NPS 2, NPS 3, NPS 4, or NPS 6 (DN 50, DN 80, DN 100, or DN 150) outlet as indicated.
  8. High-Silicon-Iron Cleanouts:
    - a. Standard: ASTM A 861, fitting with PTFE gasket and closure plug, of design appropriate for piping application.
  9. Stainless-Steel Cleanouts:
    - a. Standard: ASME A112.3.1, ASTM A 666, Type 316L, stainless steel.
    - b. Aboveground Piping: Cleanout tee of size matching piping.
    - c. Underground and Underslab Piping: Floor access cleanout of size matching piping.
  10. High-Silicon-Iron Backwater Valves:
    - a. Standard: ASTM A 861.
    - b. Body: Hub-and-plain end with swing-check valve; and with high-silicon-iron pipe extension of length to reach floor surface, and high-silicon-iron closure plug, **as directed**.
  11. Plastic Backwater Valves:
    - a. Description: Full-port NPS 3 (DN 80) check valve, PP or PVDF, matching or compatible with system piping and compatible with system liquid, with EPDM seals and flanged ends.
      - 1) Exception: PVC material for use with PVC piping systems.
  12. High-Silicon-Iron Sink Outlets:
    - a. Standard: ASTM A 861, high-silicon iron, NPS 1-1/2 (DN 40), with clamping device and 4-, 6-, or 8-inch- (100-, 150-, or 200-mm-) high overflow fitting, as indicated.
  13. PP Sink Outlets:
    - a. Description: NPS 1-1/2 (DN 40), with clamping device, stopper, and 7-inch- (178-mm-) high overflow fitting.
  14. Glass Sink Outlets:
    - a. Standard: ASTM C 1053, components for field assembly, NPS 1-1/2 (DN 40); with sink assembly of outlet, strainer, gasket, and locknut; overflow fitting of length indicated; and tailpiece assembly of borosilicate glass and locknut.
- F. Neutralization Tanks
1. Plastic Neutralization Tanks:
    - a. Description: Corrosion-resistant plastic materials; with removable, gastight cover; interior, sidewall, dip-tube inlet; outlet; vent; and threaded or flanged, sidewall pipe connections.
      - 1) Material: HDPE OR ASTM D 4101, PP, **as directed**.
      - 2) Tank Capacity: as directed by the Owner.
      - 3) Dip Tube: On outlet pipe instead of inlet pipe.
      - 4) Extension: HDPE, PE, or PP.
      - 5) Traffic Cover: Light-duty OR Heavy-duty pedestrian or light-duty vehicular, steel plate over, **as directed**, plastic, bolted.
      - 6) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.
- OR**

Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

2. Ceramic Neutralization Tanks:

a. Description: Corrosion-resistant, cast-ceramic shell; with removable, reinforced-plastic, gastight cover; inlet; interior, sidewall, dip-tube outlet; vent; and bell, sidewall pipe connections.

1) Extension: Ceramic, of size and length indicated, and with cast-iron manhole frame and cover.

**OR**

Extension: Steel with protective coating, 28-inch (710-mm) diameter, and cast-iron manhole frame and cover.

2) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

**OR**

Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

3. Collection Tanks: Corrosion-resistant, cast-ceramic shell. Include removable, reinforced-plastic, gastight cover; inlet; vent; and bell, sidewall pipe connections.

a. Extension: Ceramic **OR** Steel with protective coating, **as directed**, 28-inch (710-mm) minimum diameter, and cast-iron manhole frame and cover.

G. Neutralization Systems

1. Plastic-Tank Neutralization Systems:

a. Description: Automatic system for neutralizing chemical waste.

1) Controls: Factory-wired and -tested, 120-V ac, to operate probes, control valves, and metering pumps and to monitor pH of effluent; with wiring and electrical-power terminals.

2) Panel: NEMA 250, Type 4X enclosure, unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, but not less than the following:

a) Power light and on/off switch.

b) pH analyzer with meter and high- and low-pH indicators.

c) Low caustic- and acid-solution level indicators.

d) Alarm horn with silencer and reset switch.

e) Agitator running light with on/off switch.

f) Running lights with on/off switches for caustic- and acid-solution pumps.

3) Strip chart recorder with capacity for 30-day record.

4) Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.

5) Interceptor Tank: Same material as mixing tank; with removable, gastight cover; and sidewall inlet and outlet piping connections.

6) Neutralization Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and vent connection in sidewall or top.

a) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

**OR**

Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and 1- to 3-inch (25- to 75-mm) diameter.

7) Mixing Tank: With removable, gastight cover; sidewall inlet and outlet piping connections; vent connection in sidewall or top; neutralizing-solution piping connections; and openings in top for probe and agitator.



- a) Material: HDPE **OR** ASTM D 4101, PP, **as directed**.
    - b) pH Probe: Type and length suitable for mixing-tank size.
    - c) Agitator: Electric, with stainless-steel shaft and propeller.
  - 8) Caustic-Solution Storage Tank: PP.
    - a) Caustic Chemical: Sodium hydroxide solution.
  - 9) Acid Storage Tank: PP.
    - a) Acid Chemical: Sulfuric acid solution.
  - 10) Metering Pumps: Types suitable for neutralizing solutions.
  - 11) Sampling Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and opening in top for probe.
    - a) pH probe: Type and length suitable for sampling-tank size.
2. Ceramic-Tank Neutralization Systems:
  - a. Description: Automatic system for neutralizing chemical waste.
    - 1) Controls: Factory-wired and -tested, 120-V ac, to operate probes, control valves, and metering pumps and to monitor pH of effluent; with wiring and electrical-power terminals.
    - 2) Panel: NEMA 250, Type 4X enclosure, unless otherwise indicated; with manufacturer's standard features, control devices, and indicators, including the following:
      - a) Power light and on/off switch.
      - b) pH analyzer with meter and high- and low-pH indicators.
      - c) Low caustic- and acid-solution level indicators.
      - d) Alarm horn with silencer and reset switch.
      - e) Agitator running light with on/off switch.
      - f) Running lights with on/off switches for caustic- and acid-solution pumps.
    - 3) Strip chart recorder with capacity for 30-day record.
    - 4) Piping between Tanks: Same material as chemical-waste piping system unless otherwise indicated.
    - 5) Interceptor Tank: Same material as mixing tank; with removable, gastight cover; and sidewall inlet and outlet piping connections.
    - 6) Neutralization Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and vent connection in sidewall or top.
      - a) Limestone: Chips or lumps, with more than 90 percent calcium carbonate content and **1- to 3-inch (25- to 75-mm)** diameter.
      - OR**
      - Dolomitic Limestone: Chips or lumps, with more than 90 percent combined magnesium carbonate and calcium carbonate content and **1- to 3-inch (25- to 75-mm)** diameter.
    - 7) Mixing Tank: With removable, gastight cover; sidewall inlet and outlet piping connections; vent connection in sidewall or top; neutralizing-solution piping connections; and openings in top for probe and agitator.
      - a) Material: Clay, vitrified into ceramic unit.
      - b) pH Probe: Type and length suitable for mixing tank size.
      - c) Agitator: Electric, with stainless-steel shaft and propeller.
    - 8) Caustic-Solution Storage Tank: PP.
      - a) Caustic Chemical: Sodium hydroxide solution.
    - 9) Acid Storage Tank: PP.
      - a) Acid Chemical: Sulfuric acid solution.
    - 10) Metering Pumps: Types suitable for neutralizing solutions.
    - 11) Sampling Tank: Same material as mixing tank; with removable, gastight cover; sidewall inlet and outlet piping connections; and opening in top for probe.
      - a) pH probe: Type and length suitable for sampling-tank size.

#### H. Manholes

1. Description: ASTM F 1759, fabricated from PE components. Include bottom, sidewalls, and top sections; corrosion-resistant, manhole frame and cover; fusion or other watertight joints; and design to prohibit flotation.
    - a. Construction: Single wall **OR** Double wall with interstitial space, **as directed**.
    - b. Bottom: Channeled.
    - c. Connections: Inlets and outlet matching or suitable for piping.
    - d. Steps: Manufacturer's standard, fusion welded to sidewall. Omit steps for manholes less than **60 inches (1500 mm)** deep.
    - e. Top: Include **24-inch- (610-mm-)** nominal-diameter frame and cover.
- I. Leak-Detection Systems
1. Leak-Detection Systems:
    - a. Description: Cable leak-detection system capable of detecting and annunciating fluid leaks; with controls, panel, wiring, cable sensors, probes if required, and piping.
      - 1) Annunciator Panel: Enclosure with visual and audible alarms and leak location indicator.
      - 2) Sensors: Electric cable, suitable for insertion into double-containment piping annular space, with capability of detecting fluid leaks and signaling locations of leaks.
- J. Sleeves
1. Cast-Iron Wall Pipes: Cast or fabricated of cast iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
  2. Galvanized-Steel-Sheet Sleeves: **0.0239-inch (0.6-mm)** minimum thickness; round tube closed with welded longitudinal joint.
  3. PVC-Pipe Sleeves: ASTM D 1785, Schedule 40.
  4. Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, plain ends.
  5. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
    - a. Underdeck Clamp: Clamping ring with set screws.
- K. Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
    - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
    - b. Pressure Plates: Carbon steel **OR** Plastic **OR** Stainless steel, **as directed**.
    - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements.
- L. Escutcheons
1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
  2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
  3. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
  4. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
  5. One-Piece, Floor-Plate Escutcheons: Cast iron.
  6. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.
- M. Grout
1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

- a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
- b. Design Mix: **5000-psi (34.5-MPa)**, 28-day compressive strength.
- c. Packaging: Premixed and factory packaged.

### 1.3 EXECUTION

#### A. Earthwork

- 1. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

#### B. Concrete Bases

- 1. Anchor neutralization tanks and neutralization system tanks to concrete bases.
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **19-inch (480-mm)** centers around full perimeter of base.
  - b. For installed equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be imbedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - e. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit.
  - f. Use **3000-psi (20.7-MPa)**, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
  - g. Comply with requirements in Division 31 for cast-in-place concrete materials and placement.

#### C. Piping Installation

- 1. Chemical-Waste Sewerage Outside the Building:
  - a. Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground chemical-waste sewerage piping. Location and arrangement of piping layout take design considerations into account. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
  - b. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for using lubricants, cements, and other installation requirements.
  - c. Install manholes for changes in direction, unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
  - d. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
  - e. Tunneling: Install pipe under streets or other obstructions that cannot be disturbed by tunneling, jacking, or combination of both.
  - f. Install drainage piping pitched down in direction of flow, at minimum slope of **1 OR 2, as directed**, percent, unless otherwise indicated.
  - g. Install drainage piping with **36-inch (915-mm) OR 48-inch (1220-mm) OR 60-inch (1524-mm) OR 72-inch (1830-mm)**, **as directed**, minimum cover.
  - h. Install PE drainage piping according to ASTM D 2321 and ASTM F 1668.
  - i. Install PVC drainage piping according to ASTM D 2321 and ASTM F 1668.
  - j. Install PVDF drainage piping according to ASTM D 2321 and ASTM F 1668.
  - k. Install fiberglass piping according to ASTM D 3839 and ASTM F 1668.
  - l. Install field-fabrication containment piping over new and existing carrier piping. Use containment piping manufacturer's fastening system.

- m. Clear interior of piping and structures of dirt and superfluous material as work progresses. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plug in end of incomplete piping at end of day and when work stops.
- 2. Chemical-Waste Piping Inside the Building:
  - a. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
  - b. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
  - c. Flanges may be used on aboveground piping unless otherwise indicated.
  - d. Install underground fiberglass piping according to ASTM D 3839.
  - e. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
  - f. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
  - g. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
  - h. Install piping at indicated slopes.
  - i. Install piping free of sags and bends.
  - j. Install fittings for changes in direction and branch connections.
  - k. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
    - 1) New Piping:
      - a) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
      - b) Insulated Piping: One-piece, stamped-steel type with spring clips.
      - c) Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
      - d) Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge **OR** One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
      - e) Bare Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
      - f) Bare Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
      - g) Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
    - 2) Existing Piping:
      - a) Insulated Piping: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and spring clips.
      - b) Bare Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
      - c) Bare Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
      - d) Bare Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
      - e) Bare Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
      - f) Bare Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
  - l. Sleeves are not required for core-drilled holes.
  - m. Permanent sleeves are not required for holes formed by removable PE sleeves.
  - n. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.

**OR**

Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.

- 1) Cut sleeves to length for mounting flush with both surfaces.
  - a) Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas **2 inches (50 mm)** above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
- 2) Install sleeves in new walls and slabs as new walls and slabs are constructed.
- 3) Install sleeves that are large enough to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
  - a) **PVC OR Steel, as directed**, Pipe Sleeves: For pipes smaller than **NPS 6 (DN 150)**.
  - b) Steel Sheet Sleeves: For pipes **NPS 6 (DN 150)** and larger, penetrating gypsum board partitions.
  - c) Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to **2 inches (50 mm)** above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing And Trim" for flashing.
  - d) Seal space outside of sleeve fittings with grout.
- o. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
  - 1) Install steel pipe for sleeves smaller than **6 inches (150 mm)** in diameter.
  - 2) Install cast-iron "wall pipes" for sleeves **6 inches (150 mm)** and larger in diameter.
  - 3) Sleeve-Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- p. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
  - 1) Sleeve-Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- q. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- r. Verify final equipment locations for roughing-in.

**D. Piping Specialty Installation**

1. Embed floor drains in **4-inch (100-mm)** minimum depth of concrete around bottom and sides. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for concrete.
2. Fasten grates to drains if indicated.
3. Set floor drains with tops flush with pavement surface.
4. Install cleanouts and riser extension from sewer pipe to cleanout at grade. Use fittings of same material as sewer pipe at branches for cleanouts and riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in pipe.

- a. Set cleanout bodies in earth in cast-in-place concrete block, **18 by 18 by 12 inches (450 by 450 by 300 mm)** deep. Set with tops **1 inch (25 mm)** above surrounding grade. Set cleanout plugs in concrete pavement with tops flush with pavement surface. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for formwork, reinforcement, and concrete requirements.
  5. Install backwater valves in horizontal position. Include riser to cleanout at grade.
- E. Joint Construction
  1. Chemical-Waste Sewerage Outside the Building:
    - a. Plastic-Piping, Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
    - b. Make fiberglass-piping bonded joints according to ASTM D 3839.
    - c. Make fiberglass butt-and-wrap joints according to ASTM D 3839.
    - d. Join dissimilar pipe materials with adapters compatible with pipe materials being joined.
    - e. Join high-silicon-iron, hub-and-plain-end piping with calked joints using acid-resistant packing and lead.
    - f. Join high-silicon-iron, mechanical-joint piping with coupled joints using clamps and sleeves.
    - g. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
  2. Chemical-Waste Piping Inside the Building:
    - a. Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.
    - b. Fiberglass-Piping Joints: Make joints with piping manufacturer's bonded adhesive.
    - c. Dissimilar-Material Piping Joints: Make joints using adapters compatible with both system materials.
    - d. Join high-silicon-iron, hub-and-plain-end piping with calked joints using acid-resistant packing and lead.
    - e. Join high-silicon-iron, mechanical-joint piping with coupled joints using clamps and sleeves.
    - f. PVC Nonpressure Piping Joints: Join piping according to ASTM D 2665.
- F. Hanger And Support Installation
  1. Pipe sizes in this article refer to aboveground, single-wall piping and carrier piping of containment piping, **as directed**.
  2. Comply with requirements in Division 22 Section "Vibration And Seismic Controls For Plumbing Piping And Equipment" for seismic-restraint devices.
  3. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for pipe hanger and support devices. Install the following:
    - a. Vertical Piping: MSS Type 8 or MSS Type 42, riser clamps.
    - b. Individual, Straight, Horizontal Piping Runs:
      - 1) **100 Feet (30 m)** and Less: MSS Type 1, adjustable, steel clevis hangers.
      - 2) Longer Than **100 Feet (30 m)**: MSS Type 43, adjustable roller hangers.
      - 3) Longer Than **100 Feet (30 m)**, if Indicated: MSS Type 49, spring cushion rolls.
    - c. Multiple, Straight, Horizontal Piping Runs **100 Feet (30 m)** or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
    - d. Base of Vertical Piping: MSS Type 52, spring hangers.
  4. Comply with requirements in Division 22 Section "Hangers And Supports For Plumbing Piping And Equipment" for installation of supports.
  5. Support horizontal piping and tubing within **12 inches (300 mm)** of each fitting and coupling.
  6. Support vertical piping and tubing at base and at each floor.
  7. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of **3/8 inch (10 mm)**.
  8. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:
    - a. **NPS 2 (DN 50): 33 inches (840 mm)** with **3/8-inch (10-mm)** rod.
    - b. **NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm)** with **1/2-inch (13-mm)** rod.



- c. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
  - d. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
  - e. NPS 8 (DN 200): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.
9. Install supports for vertical PP piping every 72 inches (1830 mm).
10. Install vinyl-coated hangers for PVC piping with the following maximum horizontal spacing and minimum rod diameters:
  - a. NPS 1-1/4 (DN 32): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
  - b. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 42 inches (1067 mm) with 3/8-inch (10-mm) rod.
  - c. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.
  - d. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
  - e. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
  - f. NPS 8 to NPS 12 (DN 200 to DN 300): 48 inches (1220 mm) with 7/8-inch (22-mm) rod.
11. Install supports for vertical PVC piping every 48 inches (1220 mm).
12. Install vinyl-coated hangers for PVDF piping with the following maximum horizontal spacing and minimum rod diameters:
  - a. All Sizes: Install continuous support for piping with liquid waste at temperatures above 140 deg F (60 deg C).
  - b. NPS 1/2 (DN 15) and Smaller: 30 inches (760 mm) with 3/8-inch (10-mm) rod.
  - c. NPS 3/4 to NPS 1-1/2 (DN 20 to DN 40): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
  - d. NPS 2 (DN 50): 36 inches (910 mm) with 3/8-inch (10-mm) rod.
  - e. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 42 inches (1067 mm) with 1/2-inch (13-mm) rod.
  - f. NPS 4 and NPS 5 (DN 100 and DN 125): 48 inches (1220 mm) with 5/8-inch (16-mm) rod.
  - g. NPS 6 (DN 150): 48 inches (1220 mm) with 3/4-inch (19-mm) rod.
13. Install supports for vertical PVDF piping NPS 1-1/2 (DN 40) every 48 inches (1220 mm) and NPS 2 (DN 50) and larger every 72 inches (1830 mm).
14. Install vinyl-coated hangers for fiberglass piping with the following maximum horizontal spacing and minimum rod diameters:
  - a. NPS 2 (DN 50) and Smaller: 10 feet (3 m) with 3/8-inch (10-mm) rod.
  - b. NPS 2-1/2 and NPS 3 (DN 65 and DN 80): 10 feet (3 m) with 1/2-inch (13-mm) rod.
  - c. NPS 4 and NPS 5 (DN 100 and DN 125): 10 feet (3 m) with 5/8-inch (16-mm) rod.
  - d. NPS 6 (DN 150): 10 feet (3 m) with 3/4-inch (19-mm) rod.
  - e. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet (3.6 m) with 7/8-inch (22-mm) rod.
15. Install supports for vertical fiberglass piping every 12 feet (3.6 m).
16. Install hangers for stainless-steel drainage piping with the following maximum horizontal spacing and minimum rod diameters:
  - a. NPS 2 (DN 50): 10 feet (3 m) with 3/8-inch (10-mm) rod.
  - b. NPS 2-1/2 (DN 65): 11 feet (3.4 m) with 1/2-inch (13-mm) rod.
  - c. NPS 3 (DN 80): 12 feet (3.6 m) with 1/2-inch (13-mm) rod.
  - d. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet (3.6 m) with 5/8-inch (16-mm) rod.
  - e. NPS 6 (DN 150): 12 feet (3.6 m) with 3/4-inch (19-mm) rod.
17. Install supports for vertical stainless-steel drainage piping every 15 feet (4.5 m).
18. Install hangers for high-silicon-iron piping with the following maximum horizontal spacing and minimum rod diameters:
  - a. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches (1520 mm) with 3/8-inch (10-mm) rod.
  - b. NPS 3 (DN 80): 60 inches (1520 mm) with 1/2-inch (13-mm) rod.
  - c. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches (1520 mm) with 5/8-inch (16-mm) rod.
  - d. NPS 6 (DN 150): 60 inches (1520 mm) with 3/4-inch (19-mm) rod.
  - e. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches (1520 mm) with 7/8-inch (22-mm) rod.
  - f. NPS 15 (DN 375): 60 inches (1520 mm) with 1-inch (25-mm) rod.
  - g. Spacing for horizontal pipe in 84-inch (2134-mm) lengths may be increased to 84 inches (2134 mm). Spacing for fittings is limited to 60 inches (1520 mm).

19. Install supports for vertical high-silicon-iron piping every **15 feet (4.5 m)**.
20. Install vinyl-coated hangers for glass piping with the following maximum horizontal spacing and minimum rod diameters:
  - a. **NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches (1830 mm)** with **3/8-inch (10-mm)** rod.
  - b. **NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches (2440 mm)** with **3/8-inch (10-mm)** rod.
  - c. **NPS 3 (DN 80): 96 inches (2440 mm)** with **1/2-inch (13-mm)** rod.
  - d. **NPS 4 and NPS 6 (DN 100 and DN 150): 96 inches (2440 mm)** with **5/8-inch (16-mm)** rod.
21. Install supports for vertical glass piping every **96 inches (2440 mm)**.
22. Support piping and tubing not listed above according to MSS SP-69.

#### G. Neutralization Tank Installation

1. Install exterior collection **OR** neutralization, **as directed**, tanks, complete with appurtenances indicated.
  - a. Set tops of tank covers flush with finished surface where covers occur in pavements. Set covers **3 inches (76 mm)** above finished surface elsewhere unless otherwise indicated.
  - b. Include initial fill of limestone for neutralization tanks.
2. Install interior neutralization tanks on smooth and level concrete base **OR** floor surface, **as directed**. Include full initial charge of limestone.

#### H. Neutralization System Installation

1. Install neutralization systems on smooth and level concrete base **OR** floor surface, **as directed**. Include neutralizing solutions and full initial charge of limestone.

#### I. Manhole Installation

1. General: Install manholes, complete with appurtenances and accessories indicated. Comply with requirements in Division 22 Section "Facility Sanitary Sewers".
2. Set tops of manhole frames and covers flush with finished surface where manholes occur in pavements. Set tops **3 inches (76 mm)** above finished surface elsewhere unless otherwise indicated.

#### J. Leak-Detection System Installation

1. Single-Pipe, Chemical-Waste Sewerage Piping: Install leak-detection system below piping.
2. Double-Containment Piping: Install leak-detection system in piping annular space.
3. Manholes: Install leak-detection system around bottom of exterior.
4. Install panel in location indicated.

#### K. Concrete Placement

1. Comply with requirements in Division 03 Section "Cast-in-place Concrete" for concrete supports.
2. Place cast-in-place concrete according to ACI 318/318R.

#### L. Connections

1. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Make connections to existing piping so finished Work complies as nearly as practical with requirements specified for new Work.
3. Use commercially manufactured wye fittings for sewerage piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting plus **6-inch (150-mm)** overlap, with not less than **6 inches (150 mm)** of concrete with 28-day compressive strength of **3000 psi (20.7 MPa)**.
4. Protect existing piping to prevent concrete or debris from entering while making connections. Remove debris or other extraneous material that may accumulate.
5. Install piping adjacent to equipment to allow service and maintenance.

M. Labeling And Identification

1. Comply with requirements in Division 22 Section "Identification For Plumbing Piping And Equipment" for labeling of equipment and piping.
  - a. Use warning tape **OR** detectable warning tape, **as directed**, over ferrous piping.
  - b. Use detectable warning tape over nonferrous piping and over edges of underground structures.

N. Field Quality Control

1. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately **24 inches (610 mm)** of backfill is in place and again at completion of Project.
  - a. Defects requiring correction include the following:
    - 1) Alignment: Less than full diameter of inside of pipe is visible between inspection points.
    - 2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    - 3) Crushed, broken, cracked, or otherwise damaged piping.
    - 4) Hydrostatic Tests for Drainage Piping:
      - a) Allowable leakage is a maximum of **50 gal./inch of nominal pipe size per mile (4.6 L/mm of nominal pipe size per kilometer)** of pipe, during 24-hour period.
      - b) Close openings in system and fill with water.
      - c) Purge air and refill with water.
      - d) Disconnect water supply.
      - e) Test and inspect joints for leaks.
    - 5) Air Tests for Drainage Piping: Comply with UNI-B-6.
  - b. Leaks and loss in test pressure constitute defects that must be repaired.
  - c. Submit separate reports for each test.
2. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.
3. Perform tests and inspections.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
4. Tests and Inspections:
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect assembled neutralization systems and leak-detection systems and their installation, including piping and electrical connections, and to assist in testing.
  - b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
5. Chemical-waste piping will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports.

O. Startup Service

1. Perform startup service for neutralization systems and leak-detection systems.
  - a. Complete installation and startup checks according to manufacturer's written instructions.
  - b. Neutralization Systems:
    - 1) Verify that neutralization system is installed and connected according to the Contract Documents.
    - 2) Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 22.
    - 3) Install neutralizing solutions and limestone.
    - 4) Energize circuits.
    - 5) Start and run systems through complete sequence of operations.

- 6) Adjust operating controls.
- c. Leak-Detection Systems:
  - 1) Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 22.
  - 2) Energize circuits.
  - 3) Adjust operating controls.
- P. Adjusting
  1. Adjust neutralization-system set points.
  2. Adjust leak-detection-system control and device settings.
- Q. Cleaning
  1. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:
    - a. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
    - b. Clean piping by flushing with potable water.
- R. Demonstration
  1. Train the Owner's maintenance personnel to adjust, operate, and maintain neutralization systems and leak-detection systems.
- S. Piping Schedule
  1. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used in applications below unless otherwise indicated.
  2. Single-Wall, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:
    - a. **NPS 2 to NPS 4 (DN 50 to DN 100):** High-silicon-iron, hub-and-plain-end pipe and fittings and calked **OR** High-silicon-iron, mechanical-joint pipe and fittings and coupled, **as directed**, joints.
    - b. **NPS 2 to NPS 4 (DN 50 to DN 100):** Stainless-steel drainage pipe and fittings and gasketed joints.
    - c. **NPS 1-1/2 to NPS 4 (DN 40 to DN 100):** PE drainage pipe and fittings and heat-fusion joints.
    - d. **NPS 1-1/2 to NPS 4 (DN 40 to DN 100):** PP drainage pipe and fittings and electrofusion joints.
    - e. **NPS 1-1/2 to NPS 4 (DN 40 to DN 100):** PVC drainage pipe and fittings and solvent-cemented joints.
    - f. **NPS 1-1/2 to NPS 4 (DN 40 to DN 100):** PVDF drainage pipe and fittings and electrofusion joints.
    - g. **NPS 2 to NPS 4 (DN 50 to DN 100):** Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
    - h. **NPS 1-1/2 to NPS 4 (DN 40 to DN 100):** Glass pipe and fittings and coupled joints.
    - i. **NPS 6 (DN 150):** High-silicon-iron, hub-and-plain-end pipe and fittings and calked **OR** High-silicon-iron, mechanical-joint pipe and fittings and coupled, **as directed**, joints.
    - j. **NPS 6 (DN 150):** Stainless-steel drainage pipe and fittings and gasketed joints.
    - k. **NPS 6 (DN 150):** PE drainage pipe and fittings and heat-fusion joints.
    - l. **NPS 6 (DN 150):** PP drainage pipe and fittings and electrofusion joints.
    - m. **NPS 6 (DN 150):** PVC drainage pipe and fittings and solvent-cemented joints.
    - n. **NPS 6 (DN 150):** PVDF drainage pipe and fittings and electrofusion joints.
    - o. **NPS 6 (DN 150):** Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
    - p. **NPS 6 (DN 150):** Glass pipe and fittings and coupled joints.

- q. **NPS 8 to NPS 12 (DN 200 to DN 300):** High-silicon-iron, hub-and-plain-end pipe and fittings and calked joints.
  - r. **NPS 8 to NPS 12 (DN 200 to DN 300):** PP drainage pipe and fittings and electrofusion joints.
  - s. **NPS 8 to NPS 12 (DN 200 to DN 300):** PVC drainage pipe and fittings and solvent-cemented joints.
  - t. **NPS 8 to NPS 12 (DN 200 to DN 300):** PVDF drainage pipe and fittings and electrofusion joints.
  - u. **NPS 8 to NPS 12 (DN 200 to DN 300):** Centrifugally cast **OR** Filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
  - v. **NPS 15 (DN 375):** High-silicon-iron, hub-and-plain-end pipe and fittings and calked joints.
  - w. **NPS 15 (DN 375): NPS 16 (DN 400)** centrifugally cast **OR NPS 14 (DN 350)** filament-wound, **as directed**, fiberglass pipe and fittings and butt-and-wrap **OR** bonded, **as directed**, joints.
3. Underground, Double-Containment, Chemical-Waste Sewerage Piping: Use any of the following piping materials for each size range:
- a. **NPS 2 to NPS 12 (DN 50 to DN 300):** PE double-containment drainage pipe and fittings.
  - b. **NPS 2 to NPS 12 (DN 50 to DN 300):** PP double-containment drainage pipe and fittings.
  - c. **NPS 2 to NPS 12 (DN 50 to DN 300):** PP/PVC double-containment drainage pipe and fittings.
  - d. **NPS 2 to NPS 12 (DN 50 to DN 300):** PVDF double-containment drainage pipe and fittings.
  - e. **NPS 2 to NPS 12 (DN 50 to DN 300):** PVDF/PVC double-containment drainage pipe and fittings.
4. Aboveground Chemical-Waste Piping: Use any of the following piping materials for each size range:
- a. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** PP drainage piping and electrofusion **OR** mechanical, **as directed**, joints.
  - b. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** PVC drainage piping and solvent-cemented joints.
  - c. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** PVDF drainage piping and electrofusion **OR** mechanical, **as directed**, joints.
  - d. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 6 (DN 50 to DN 150)** high-silicon-iron piping with hub-and-plain ends and calked joints.
  - e. **NPS 1-1/2 to NPS 4 (DN 40 to DN 100):** High-silicon-iron piping with mechanical-joint ends, mechanical couplings, and coupled joints.
  - f. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100)** stainless-steel drainage piping with socket-and-spigot ends and gasketed joints.
  - g. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** Borosilicate glass pipe and fittings, couplings, and coupled joints.
  - h. **NPS 8 to NPS 12 (DN 200 to DN 300):** PVC drainage pipe and fittings and solvent-cemented joints.
  - i. **NPS 8 to NPS 12 (DN 200 to DN 300):** High-silicon-iron piping with hub-and-plain ends and calked joints.
5. Under Slab-on-Grade, Indoor, Chemical-Waste Piping: Use any of the following piping materials for each size range:
- a. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** PP drainage piping and electrofusion joints.
  - b. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** PVC drainage piping and solvent-cemented joints.
  - c. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** PVDF drainage piping and electrofusion joints.
  - d. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100)** high-silicon-iron piping with hub-and-plain ends and calked joints.
  - e. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150): NPS 2 to NPS 4 (DN 50 to DN 100)** stainless-steel drainage piping with socket-and-spigot ends and gasketed joints.





- f. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** Borosilicate glass piping with covering, couplings, and coupled joints.
- g. **NPS 1-1/2 to NPS 6 (DN 40 to DN 150):** PE **OR** PP **OR** PP/PVC **OR** PVDF **OR** PVDF/PVC, **as directed**, double-containment drainage piping and manufacturer's standard joints.
- h. **NPS 8 (DN 200):** PVC drainage piping and solvent-cemented joints.
- i. **NPS 8 (DN 200):** High-silicon-iron piping with hub-and-plain ends and calked joints.
- j. **NPS 8 (DN 200):** PE **OR** PP **OR** PP/PVC **OR** PVDF **OR** PVDF/PVC, **as directed**, double-containment drainage piping and manufacturer's standard joints.
- k. **NPS 10 and NPS 12 (DN 250 and DN 300):** PVC drainage piping and solvent-cemented joints.
- l. **NPS 10 to NPS 15 (DN 250 to DN 375):** High-silicon-iron piping with hub-and-plain ends and calked joints.

END OF SECTION 22 66 83 16



## SECTION 23 01 10 91 - SEQUENCE OF OPERATION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for sequence of operation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes control sequences for HVAC systems, subsystems, and equipment.

#### C. Definitions

1. DDC: Direct digital control.
2. VAV: Variable air volume.

#### D. Heating Control Sequences

1. Heating-Water Supply Temperature Control:
  - a. Input Device: Thermostat **OR** Thermistor temperature sensor **OR** Resistance temperature sensor, **as directed**.
  - b. Output Device: Control valve.
  - c. Action: Modulate control valve to maintain heating-water supply temperature.
  - d. Display:
    - 1) Heating-water supply temperature.
    - 2) Heating-water supply temperature set point.
    - 3) Control-valve position.
2. Heating-Water Supply Temperature Reset:
  - a. Input Device: Electric, outdoor-air-reset controller **OR** Outdoor-air sensor, **as directed**.
  - b. Output Device: Unitary controller **OR** DDC system software, **as directed**.
  - c. Action: Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:
    - 1) 195 deg F (90 deg C) heating water when outdoor-air temperature is minus 30 deg F (minus 35 deg C).
    - 2) 130 deg F (54 deg C) heating water when outdoor-air temperature is 75 deg F (24 deg C).
    - 3) 150 deg F (65 deg C) minimum, heating-water temperature.
  - d. Display:
    - 1) Outdoor-air temperature.
    - 2) Heating-water supply temperature.
    - 3) Heating-water supply temperature set point.
3. Control Primary Circulating Pump(s):
  - a. Input Device: Thermostat **OR** DDC system, **as directed**.
  - b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
  - c. Action: Energize pump(s) at outdoor-air temperatures below 65 deg F (18 deg C).
  - d. Display:
    - 1) Outdoor-air temperature.
    - 2) Operating status of primary circulating pump(s).

#### E. Central Refrigeration Equipment Sequences

1. Start and Stop Condenser-Water Pump(s):
  - a. Enable: Allow pump to start when water is in cooling tower:
    - 1) Input Device: Water pressure transducer.

- 2) Output Device: Hard wired through motor starter; DDC system binary output, **as directed**.
- 3) Action: Confirm water in cooling-tower sump.
- b. Enable: When outdoor-air temperature conditions are met:
  - 1) Input Device: Space thermostat **OR** DDC system outdoor-air temperature, **as directed**.
  - 2) Output Device: Hard wired through motor starter; DDC system binary output, **as directed**.
  - 3) Action: Confirm outdoor-air temperature is above 50 deg F (10 deg C).
- c. Enable: When demand conditions are met:
  - 1) Input Device: DDC system software demand.
  - 2) Action: Confirm cooling demand from ventilation system(s).
- d. Initiate:
  - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
  - 2) Output Device: Time clock **OR** Binary output, **as directed**.
  - 3) Action: Energize pump(s).
- e. Display:
  - 1) Low-level cooling-tower sump alarm.
  - 2) Outdoor-air temperature.
  - 3) Cooling (software) demand indication.
  - 4) Time and time schedule.
  - 5) Condenser-water pump(s) on-off status.
  - 6) Condenser-water pump(s) on-off indication.
2. Start and Stop Chilled-Water Pump(s):
  - a. Input Device: Flow switch in condenser-water circuit.
  - b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
  - c. Action: Energize pump(s).
  - d. Display:
    - 1) Chilled-water flow indication.
    - 2) Chilled-water pump(s) on-off status.
    - 3) Chilled-water pump(s) on-off indication.
3. Start and Stop Cooling-Tower Fans(s):
  - a. Input Device: Flow switch in condenser-water circuit.
  - b. Output Device: Starter **OR** DDC system command to starter, **as directed**, relay.
  - c. Action: Energize fan(s).
  - d. Display:
    - 1) Condenser-water flow indication.
    - 2) Cooling-tower fan(s) on-off indication.
4. Start and Stop Refrigeration Machine(s):
  - a. Input Device: Flow switch in condenser-water circuit. Flow switch in chilled-water circuit, **as directed**.
  - b. Output Device: Refrigeration **OR** DDC system command to refrigeration, **as directed**, machine terminal strip.
  - c. Action: Energize refrigeration machine(s) internal control circuit.
  - d. Display:
    - e. Condenser-water flow indication.
    - f. Chilled-water flow indication.
    - g. Refrigeration machine on-off indication.
    - h. Chilled-water supply and return temperature.
    - i. Chilled-water temperature control-point adjustment.
5. Start and Stop Chiller(s):
  - a. Input Device: Flow switches in condenser-water and chilled-water circuit.
  - b. Output Device: Chiller **OR** DDC system command to chiller, **as directed**, terminal strip.
  - c. Action: Energize chiller internal control circuit.

- d. Display:
  - 1) Condenser-water flow indication.
  - 2) Chilled-water flow indication.
  - 3) Chiller(s) on-off status.
  - 4) Chiller(s) on-off indication.
  - 5) Chilled-water supply and return temperature.
  - 6) Chilled-water temperature control-point adjustment.
- 6. Alternate Chiller(s):
  - a. Input Device: Electric alternator **OR** DDC system software, **as directed**.
  - b. Output Device: Chiller **OR** DDC system command to chiller, **as directed**, terminal strip.
  - c. Action: Operate chiller(s) on lead-lag, alternating each startup.  
**OR**  
Action: Adding and dropping chiller(s) as follows: **<Insert sequence and parameters.>**
  - d. Display: Chiller(s) on-off indication.
- 7. Alarm Chiller(s) Start Failure:
  - a. Input Device: Chiller control panel terminal strip contact **OR** software signal, **as directed**.
  - b. Output Device: Analog control panel **OR** DDC system alarm, **as directed**.
  - c. Action: Signal alarm.
  - d. Display: Chiller "failure-to-start" indication.
- 8. Chilled-Water Level:
  - a. Input Device: Expansion tank level switch **OR** liquid sensor, **as directed**.
  - b. Output Device: Electric relay signal to alarm panel **OR** DDC system alarm, **as directed**.
  - c. Action: Signal alarm.
  - d. Display: Expansion tank low-level alarm.
- 9. Chilled-Water Supply Temperature:
  - a. Input Device: Temperature sensor **OR** transmitter, **as directed**, in common chilled-water supply piping.
  - b. Output Device: Integral chiller controls **OR** DDC system signal to chiller control panel, **as directed**.
  - c. Action: Maintain constant leaving chilled-water temperature reset according to highest cooling demand, **as directed**.
    - 1) Display: Chilled-water supply temperature.
- 10. Condenser-Water Temperature:
  - a. Input Device: Temperature sensor **OR** transmitter, **as directed**, in cooling-tower sump.
  - b. Output Device: Bypass control valve **OR** Cooling-tower fan starter relay **OR** DDC system command to cooling-tower fan starter relay, **as directed**.
  - c. Action: Modulate control valve open to cooling tower and closed to bypass and cycle tower fan(s) on and off **OR** and to low speed and then to high speed, **as directed**, to maintain **65 deg F (18 deg C) OR 70 deg F (21 deg C)**, **as directed**, sump temperature. Close valve when unoccupied, **as directed**.
  - d. Display:
    - 1) Condenser-water sump (return) control-point temperature.
    - 2) Condenser-water sump (return) temperature.
    - 3) Control-valve position.
    - 4) Cooling-tower fan(s) on-off indication.
    - 5) Condenser-water supply temperature.
- 11. Cooling-Tower Sump Heater:
  - a. Input Device: Sump temperature sensor **OR** transmitter, **as directed**.
  - b. Output Device: Electric relay **OR** DDC system command to electric relay, as directed, and solenoid valve, **as directed**.
  - c. Action: Energize sump heater; drain sump on low temperature, **as directed**.
  - d. Display:
    - 1) Cooling-tower sump temperature.
    - 2) Cooling-tower sump heater on-off indication.
    - 3) Cooling-tower dump indication.
- 12. Operator Station Display: Indicate the following on operator workstation display terminal:

- a. DDC system graphic.
- b. DDC system status, on-off.
- c. Low-level cooling-tower sump alarm.
- d. Outdoor-air temperature.
- e. Cooling (software) demand indication.
- f. Time and time schedule.
- g. Condenser-water pump(s) on-off status.
- h. Condenser-water pump(s) on-off indication.
- i. Condenser-water flow indication.
- j. Chilled-water pump(s) on-off status.
- k. Chilled-water pump(s) on-off indication.
- l. Cooling-tower fan(s) on-off indication.
- m. Chilled-water flow indication.
- n. Refrigeration machine on-off indication.
- o. Chilled-water supply temperature.
- p. Chilled-water return temperature.
- q. Chilled-water temperature control-point adjustment.
- r. Chiller(s) on-off status.
- s. Chiller(s) on-off indication.
- t. Chiller "failure-to-start" indication.
- u. Expansion tank low-level alarm.
- v. Condenser-water sump (return) control-point temperature.
- w. Condenser-water sump (return) temperature.
- x. Condenser-water control-valve position.
- y. Cooling-tower fan(s) on-off indication.
- z. Condenser-water supply temperature.
- aa. Cooling-tower sump temperature.
- bb. Cooling-tower sump heater on-off indication.
- cc. Cooling-tower dump indication.
- dd. Chilled-water pressure drop through chiller.
- ee. Entering condenser-water temperature.
- ff. Leaving condenser-water temperature.
- gg. Condenser-water pressure drop through chiller.
- hh. Chiller condenser-water supply and return temperature.
- ii. Chiller chilled-water supply and return temperature.
- jj. System capacity in tons.

F. Air-Handling-Unit Control Sequences

1. Start and Stop Supply Fan(s):
  - a. Enable: Freeze Protection:
    - 1) Input Device: Duct-mounted averaging element thermostat, located before supply fan.
    - 2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
    - 3) Action: Allow start if duct temperature is above **37 deg F (3 deg C)**; signal alarm if fan fails to start as commanded.
  - b. Enable: High-Temperature Protection:
    - 1) Input Device: Duct-mounted thermostat, located in return air.
    - 2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
    - 3) Action: Allow start if duct temperature is below **300 deg F (150 deg C)**.
  - c. Enable: Smoke Control:
    - 1) Input Device: Duct-mounted smoke detector, located in return **OR** supply, **as directed**, air.

- 2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
- 3) Action: Allow start if duct is free of products of combustion.
- d. Initiate: Occupied Time Schedule:
  - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
  - 2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
  - 3) Action: Energize fan(s).
- e. Initiate: Unoccupied Time Schedule:
  - 1) Input Device: Room thermostat **OR** DDC system demand, **as directed**.
  - 2) Output Device: Room thermostat **OR** Binary output, **as directed**, to motor starter.
  - 3) Action: Energize fan(s).
- f. Unoccupied Ventilation:
  - 1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
  - 2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**, to motor starter.
  - 3) Action: Cycle fan(s) during unoccupied periods.
- g. Display: Supply-fan on-off indication.
2. Supply Fan(s) Variable-Volume Control:
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.
    - 3) Action: Enable control.
  - b. Volume Control (for fans equipped with variable inlet vanes):
    - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing supply-duct static pressure referenced to conditioned-space static pressure.
    - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
    - 3) Action: Maintain constant supply-duct static pressure.
  - c. Volume Control (for fans equipped with variable-speed drives):
    - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing supply-duct static pressure referenced to conditioned-space static pressure.
    - 2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
    - 3) Action: Maintain constant supply-duct static pressure.
  - d. High Pressure:
    - 1) Input Device: Static-pressure transmitter sensing supply-duct static pressure referenced to static pressure outside the duct.
    - 2) Output Device: Receiver controller **OR** DDC system binary output, **as directed**, to alarm panel **OR** motor starter, **as directed**.
    - 3) Action: Stop fan and signal alarm when static pressure rises above excessive-static-pressure set point.
  - e. Display:
    - 1) Supply-fan-discharge static-pressure indication.
    - 2) Supply-fan-discharge static-pressure set point.
    - 3) Supply-fan airflow rate.
    - 4) Supply-fan inlet vane position **OR** speed, **as directed**.
3. Start and Stop Return Fan(s):
  - a. Initiate: Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.

- 3) Action: Energize fans when supply fans are energized.
- b. Initiate: Unoccupied Time Schedule:
  - 1) Input Device: Room thermostat **OR** DDC system demand, **as directed**.
  - 2) Output Device: Room thermostat **OR** Binary output, **as directed**, to motor starter.
  - 3) Action: Energize fans when supply fans are energized.
- c. Unoccupied Ventilation:
  - 1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
  - 2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**, to motor starter.
  - 3) Action: Cycle fan(s) during unoccupied periods.
- d. Display: Return-fan on-off indication.
4. Return Fan(s) Variable-Volume Control:
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.
    - 3) Action: Enable control.
  - b. Volume Control (for fans equipped with variable inlet vanes):
    - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
    - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
    - 3) Action: Maintain constant building static pressure.
  - c. Volume Control (for fans equipped with variable-speed drives):
    - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
    - 2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
    - 3) Action: Maintain constant building static pressure.
  - d. Display:
    - 1) Return-air static-pressure indication.
    - 2) Return-air static-pressure set point.
    - 3) Return-fan airflow rate.
    - 4) Return-fan inlet vane position **OR** speed, **as directed**.
    - 5) Building static-pressure indication.
    - 6) Building static-pressure set point.
5. Return Fan(s) Variable-Volume Control:
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.
    - 3) Action: Enable control.
  - b. Volume Control (for fans equipped with variable inlet vanes):
    - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.
    - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator. Set inlet guide vanes to minimum **OR** closed, **as directed**, position when fan is stopped.
    - 3) Action: Maintain constant building static pressure.
  - c. Volume Control (for fans equipped with variable-speed drives):
    - 1) Input Device: Static-pressure transmitter **OR** Differential-pressure switch, **as directed**, sensing building static pressure referenced to outdoor static pressure.



- 2) Output Device: Receiver controller **OR** DDC system analog output, **as directed**, to motor speed controller. Set variable-speed drive to minimum speed when fan is stopped.
- 3) Action: Maintain constant building static pressure.
- d. Display:
  - 1) Return-fan-discharge static-pressure indication.
  - 2) Return-fan-discharge static-pressure set point.
  - 3) Return-fan airflow rate.
  - 4) Return-fan inlet vane position **OR** speed, **as directed**.
6. Preheat Coil:
  - a. Freeze Protection:
    - 1) Input Device: Duct-mounted averaging element thermostat, located after preheat coil.
    - 2) Output Device: Hard wired through motor starter; analog alarm panel **OR** DDC system alarm, **as directed**.
    - 3) Action: Allow start if duct temperature is above **33 deg F (1 deg C)**.
  - b. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
    - 3) Action: Energize coil circulating pump(s).
  - c. Supply **OR** Discharge, **as directed**, Air Temperature:
    - 1) Input Device: Time clock and duct-mounted thermostat **OR** DDC system time schedule and electronic temperature sensor, **as directed**.
    - 2) Output Device: Modulating control valve.
    - 3) Action: Maintain air temperature set point of **55 deg F (13 deg C)**.
  - d. Unoccupied Time Schedule:
    - 1) Input Device: Time clock and duct-mounted thermostat mounted in outdoor air **OR** DDC system time schedule and outdoor-air temperature, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**, to motor starter.
    - 3) Action: Energize coil circulating pump(s) when outdoor-air temperature falls below **35 deg F (2 deg C)**.
  - e. Display:
    - 1) Preheat-coil air-temperature indication.
    - 2) Preheat-coil air-temperature set point.
    - 3) Preheat-coil pump operation indication.
    - 4) Preheat-coil control-valve position.
7. Mixed-Air Control:
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Pneumatic relay **OR** DDC system output, **as directed**.
    - 3) Action: Enable control.
  - b. Minimum Position:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
    - 3) Action: Open minimum outdoor-air dampers **OR** outdoor-air dampers to minimum position, **as directed**.
  - c. Heating Reset:
    - 1) Input Device: Room thermostat **OR** DDC system software, **as directed**.
    - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
    - 3) Action: Close minimum outdoor-air dampers **OR** Set outdoor-air dampers to minimum position, **as directed**.
  - d. Supply **OR** Mixed, **as directed**, Air Temperature:

- 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
- 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
- 3) Action: Modulate outdoor-, return-, and relief-air dampers to maintain air temperature set point of **55 deg F (13 deg C)**.
- e. Cooling Reset:
  - 1) Input Device: Outdoor- and return-air, duct-mounted thermostats **OR** electronic temperature sensors, **as directed**.
  - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to damper actuator(s).
  - 3) Action: Set outdoor-air dampers to minimum position when outdoor-air temperature exceeds return-air temperature **OR** enthalpy exceeds return-air enthalpy, **as directed**.
- f. Unoccupied Time Schedule:
  - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
  - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, to modulating damper actuator(s).
  - 3) Action: Position outdoor- and relief-air dampers closed and return-air dampers open.
- g. Display:
  - 1) Mixed-air-temperature indication.
  - 2) Mixed-air-temperature set point.
  - 3) Mixed-air damper position.
8. Humidifier:
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**, and airflow switch
    - 2) Output Device: Pneumatic relay **OR** DDC system output, **as directed**.
    - 3) Action: Enable control.
  - b. Humidity:
    - 1) Input Device: Room humidistat **OR** Return-air, duct-mounted humidistat **OR** DDC system, **as directed**.
    - 2) Output Device: Receiver controller **OR** DDC system analog output **OR** DDC system analog output to digital-to-pneumatic transducer, **as directed**, enables humidifier **OR** modulates control valve to maintain humidity **OR** cycles pump to maintain humidity **OR** cycles pump and modulates control valve to maintain humidity, **as directed**, in straight-line relationship for the following conditions:
      - a) 20 percent when outdoor-air temperature is **minus 30 deg F (minus 35 deg C)**.
      - b) 40 percent when outdoor-air temperature is **75 deg F (24 deg C)**.
    - 3) Action: Modulate outdoor-, return-, and relief-air dampers to maintain air temperature set point of **55 deg F (13 deg C)**.
  - c. Display:
    - 1) Relative humidity indication.
    - 2) Relative humidity set point.
    - 3) Relative humidity control-valve position.
9. Filters: During occupied periods, when fan is running, differential air-pressure transmitters exist.
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Electric relay **OR** DDC system output, **as directed**.
    - 3) Action: Enable control.
  - b. Differential Pressure:

- 1) Input Device: Differential-pressure switches **OR** Pressure transmitter, **as directed**.
- 2) Output Device: Analog alarm panel **OR** DDC system alarm, **as directed**.
- 3) Action: Signal alarm on low- and high-pressure conditions.
- c. Display:
  - 1) Filter air-pressure-drop indication.
  - 2) Filter low-air-pressure set point.
  - 3) Filter high-air-pressure set point.
10. Hydronic **OR** Steam, **as directed**, Heating Coil:
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.
    - 3) Action: Enable control.
  - b. Supply **OR** Discharge, **as directed**, -Air Temperature:
    - 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Normally open **OR** closed, **as directed**, modulating control valve.
    - 3) Action: Maintain supply-air temperature set point of **55 deg F (13 deg C)**.
  - c. Temperature Reset (for constant-temperature supply-air systems):
    - 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**, in return air.
    - 2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**, in straight-line relationship for the following conditions:
      - a) **65 deg F (18 deg C)** when return-air temperature is **70 deg F (21 deg C)**.
      - b) **55 deg F (13 deg C)** when return-air temperature is **75 deg F (24 deg C)**.
    - 3) Action: Reset supply-air temperature set point of **55 deg F (13 deg C)**.
  - d. Temperature Reset (for multizone or dual-duct supply-air systems):
    - 1) Input Device: Load analyzer **OR** DDC system, **as directed**, with input from room thermostats **OR** temperature sensors, **as directed**.
    - 2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**.
    - 3) Action: Reset supply-air temperature in response to greatest heating demand.
  - e. Unoccupied Time Schedule:
    - 1) Input Device: Time clock and room thermostat **OR** DDC system time schedule and output, **as directed**.
    - 2) Output Device: Room thermostat (cycling fan) **OR** DDC system binary output, **as directed**.
    - 3) Action: Enable normal control **OR** Return valve to normal position, **as directed**, when fan is cycled on.
  - f. Display:
    - 1) Fan-discharge air-temperature indication.
    - 2) Fan-discharge air-temperature set point.
    - 3) Heating-coil air-temperature indication.
    - 4) Heating-coil air-temperature set point.
    - 5) Heating-coil pump operation indication.
    - 6) Heating-coil control-valve position.
    - 7) Hot-deck air-temperature indication.
    - 8) Hot-deck air-temperature set point.
11. Hydronic Cooling Coil:
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.
    - 3) Action: Enable control.
  - b. Supply **OR** Discharge, **as directed**, -Air Temperature:
    - 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Normally open **OR** closed, **as directed**, modulating control valve.
    - 3) Action: Maintain supply-air temperature set point of **55 deg F (13 deg C)**.

- c. Temperature Reset (for constant-temperature systems):
  - 1) Input Device: Duct-mounted thermostat **OR** Electronic temperature sensor, **as directed**, in return air.
  - 2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**, in straight-line relationship for the following conditions:
    - a) 65 deg F (18 deg C) when return-air temperature is 70 deg F (21 deg C).
    - b) 55 deg F (13 deg C) when return-air temperature is 75 deg F (24 deg C).
  - 3) Action: Reset supply-air temperature set point of 55 deg F (13 deg C).
- d. Temperature Reset (for multizone or dual-duct supply-air systems):
  - 1) Input Device: Load analyzer **OR** DDC system, **as directed**, with input from room thermostats **OR** temperature sensors, **as directed**.
  - 2) Output Device: Direct to receiver controller **OR** DDC system, **as directed**.
  - 3) Action: Reset supply-air temperature in response to greatest heating demand.
- e. Unoccupied Time Schedule:
  - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
  - 2) Output Device: Time clock **OR** Binary output, **as directed**.
  - 3) Action: Disable control.
- f. Display:
  - 1) Fan-discharge air-temperature indication.
  - 2) Fan-discharge air-temperature set point.
  - 3) Cooling-coil air-temperature indication.
  - 4) Cooling-coil air-temperature set point.
  - 5) Cooling-coil control-valve position.
  - 6) Cold-deck air-temperature indication.
  - 7) Cold-deck air-temperature set point.
- 12. Multizone Damper Control:
  - a. Occupied Time Schedule:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.
    - 3) Action: Enable control.
  - b. Room Temperature:
    - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Damper actuator.
    - 3) Action: Maintain room temperature.
  - c. Display:
    - 1) Room temperature indication.
    - 2) Room temperature set point.
    - 3) Multizone damper position.
- 13. Coordination of Air-Handling Unit Sequences: Ensure that preheat, mixed-air, heating-coil, and cooling-coil controls have common inputs and do not overlap in function.
- 14. Operator Station Display: Indicate the following on operator workstation display terminal:
  - a. DDC system graphic.
  - b. DDC system on-off indication.
  - c. DDC system occupied/unoccupied mode.
  - d. Outdoor-air-temperature indication.
  - e. Supply-fan on-off indication.
  - f. Supply-fan-discharge static-pressure indication.
  - g. Supply-fan-discharge static-pressure set point.
  - h. Supply-fan airflow rate.
  - i. Supply-fan inlet vane position **OR** speed, **as directed**.
  - j. Return-fan on-off indication.
  - k. Return-air static-pressure indication.
  - l. Return-air static-pressure set point.
  - m. Return-fan airflow rate.
  - n. Return-fan inlet vane position **OR** speed, **as directed**.

- o. Building static-pressure indication.
- p. Building static-pressure set point.
- q. Preheat-coil air-temperature indication.
- r. Preheat-coil air-temperature set point.
- s. Preheat-coil pump operation indication.
- t. Preheat-coil control-valve position.
- u. Mixed-air-temperature indication.
- v. Mixed-air-temperature set point.
- w. Mixed-air damper position.
- x. Relative humidity indication.
- y. Relative humidity set point.
- z. Relative humidity control-valve position.
- aa. Filter air-pressure-drop indication.
- bb. Filter low-air-pressure set point.
- cc. Filter high-air-pressure set point.
- dd. Fan-discharge air-temperature indication.
- ee. Fan-discharge air-temperature set point.
- ff. Heating-coil air-temperature indication.
- gg. Heating-coil air-temperature set point.
- hh. Heating-coil pump operation indication.
- ii. Heating-coil control-valve position.
- jj. Hot-deck air-temperature indication.
- kk. Hot-deck air-temperature set point.
- ll. Cooling-coil air-temperature indication.
- mm. Cooling-coil air-temperature set point.
- nn. Cooling-coil control-valve position.
- oo. Cold-deck air-temperature indication.
- pp. Cold-deck air-temperature set point.
- qq. Room temperature indication.
- rr. Room temperature set point.
- ss. Multizone damper position.

G. Terminal Unit Operating Sequence

1. Cabinet Unit Heater, Hydronic **OR** Steam, **as directed**:
  - a. Room Temperature:
    - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**.
    - 3) Action: Cycle fan to maintain temperature.
  - b. Low-Temperature Safety:
    - 1) Input Device: Line-voltage, on-off thermostat, pipe mounted.
    - 2) Output Device: Hard wired.
    - 3) Action: Stop fan when return heating-water **OR** condensate, **as directed**, temperature falls below **35 deg F (2 deg C)**.
  - c. Display:
    - 1) Room temperature indication.
    - 2) Room temperature set point.
2. Cabinet Unit Heater, Electric: Room thermostat cycles fan and sequences stages of heating.
3. Unit Heater, Hydronic **OR** Steam, **as directed**:
  - a. Room Temperature:
    - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Room thermostat **OR** DDC system binary output, **as directed**.
    - 3) Action: Cycle fan to maintain temperature.
  - b. Low-Temperature Safety:
    - 1) Input Device: Line-voltage, on-off thermostat, pipe mounted.
    - 2) Output Device: Hard wired.



- 3) Action: Stop fan when return heating-water **OR** condensate, **as directed**, temperature falls below **35 deg F (2 deg C)**.
  - c. Display:
    - 1) Room temperature indication.
    - 2) Room temperature set point.
4. Unit Heater, Electric: Room thermostat cycles fan and sequences stages of heating.
5. Combustion-Air Unit Heaters:
  - a. Room Temperature:
    - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
    - 3) Action: Modulate valve to maintain temperature.
  - b. Display:
    - 1) Room temperature indication.
    - 2) Room temperature set point.
    - 3) Control-valve position.
6. Radiant Heating Cable, Electric: Room thermostat cycles power.
7. Radiant Heating Panel, Electric: Room thermostat cycles power.
8. Radiant Heating Panel, Hydronic:
  - a. Room Temperature:
    - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
    - 3) Action: Modulate valve to maintain temperature.
  - b. Display:
    - 1) Room temperature indication.
    - 2) Room temperature set point.
    - 3) Control-valve position.
9. Two-Pipe, Single-Coil, Fan-Coil Unit:
  - a. Occupied Time Schedule:
    - 1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.
    - 3) Action: Start and stop fan and enable control.
  - b. Room Temperature:
    - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**, in room **OR** return air, **as directed**.
    - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operator.
    - 3) Action: Modulate valve to maintain temperature.
  - c. DDC System Changeover:
    - 1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in supply-water **OR** on supply-water piping **OR** DDC system, **as directed**.
    - 2) Output Device: Hard-wired relay **OR** DDC system software, **as directed**.
    - 3) Action: Reverse control-valve action to switch from heating to cooling.
  - d. Display:
    - 1) DDC system graphic.
    - 2) DDC system on-off indication.
    - 3) DDC system occupied/unoccupied mode.
    - 4) Room temperature indication.
    - 5) Room temperature set point.
    - 6) Control-valve position.
    - 7) Supply-water temperature indication.
10. Four-Pipe, Hydronic Fan-Coil Unit:
  - a. Occupied Time Schedule:
    - 1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.



- 3) Action: Start and stop fan, and enable control.
- b. Room Temperature:
  - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
  - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators.
  - 3) Action: Modulate multiport control valves to maintain temperature.
- c. Display:
  - 1) DDC system graphic.
  - 2) DDC system on-off indication.
  - 3) DDC system occupied/unoccupied mode.
  - 4) Room temperature indication.
  - 5) Room temperature set point.
  - 6) Control-valve position.
- 11. Unit Ventilator: Room thermostat modulates heating-and-cooling control valves; airstream thermostats modulate outdoor- and return-air dampers as follows:
  - a. Occupied Time Schedule:
    - 1) Input Device: Fan switch **OR** Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Time clock **OR** Binary output, **as directed**.
    - 3) Action: Start and stop fan, move outdoor- and return-air dampers to minimum **OR** maximum, **as directed**, outdoor-air position, and enable control.
  - b. Room Temperature - Valves:
    - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators.
    - 3) Action: Modulate heating-water supply control valve and chilled-water supply control valve in sequence to maintain temperature.
  - c. Room Temperature - Dampers:
    - 1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in mixed air.
    - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control damper actuators.
    - 3) Action: Modulate outdoor- and return-air dampers to maintain temperature.
  - d. Supply-Air Temperature Limit:
    - 1) Input Device: Thermostat **OR** Electronic temperature sensor, **as directed**, in discharge air.
    - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, control-valve operators and control damper actuators.
    - 3) Action: Override room thermostat to control valves and dampers to prevent discharge air from dropping below a minimum set point.
  - e. Warm-up Cycle:
    - 1) Input Device: Time clock **OR** DDC system time schedule, **as directed**.
    - 2) Output Device: Hard-wired relay **OR** DDC system binary output, **as directed**.
    - 3) Action: Open heating-water supply control valve, close outdoor-air damper, and open return-air damper.
  - f. Display:
    - 1) DDC system graphic.
    - 2) DDC system on-off indication.
    - 3) DDC system occupied/unoccupied mode.
    - 4) Room temperature indication.
    - 5) Room temperature set point.
    - 6) Control-valve position.
    - 7) Damper position.
- 12. Heating Coils, Hydronic **OR** Steam, **as directed**:
  - a. Room Temperature:
    - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
    - 2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
    - 3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.

- b. Display:
      - 1) Room temperature indication.
      - 2) Room temperature set point.
      - 3) Control-valve position.
  13. Heating Coils, Electric: Room thermostat cycles coils **OR** sequences stages of heating, **as directed**.
  14. Radiators and Convectors, Hydronic **OR** Steam, **as directed**:
    - a. Occupancy:
      - 1) Input Device: Occupancy sensor.
      - 2) Output Device: DDC system binary output.
      - 3) Action: Report occupancy and enable occupied temperature set point.
    - b. Room Temperature:
      - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
      - 2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
      - 3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.
        - a) Occupied Temperature: 75 deg F (24 deg C).
        - b) Unoccupied Temperature: 65 deg F (18 deg C).
    - c. Display:
      - 1) Room/area served.
      - 2) Room temperature indication.
      - 3) Room temperature set point.
      - 4) Room temperature set point, occupied.
      - 5) Room temperature set point, occupied standby.
      - 6) Room temperature set point, unoccupied.
      - 7) Control-valve position as percent open.
  15. Radiators and Convectors, Electric: Room thermostat cycles coils **OR** sequences stages of heating, **as directed**.
  16. Constant-Volume, Terminal Air Units, Hydronic **OR** Steam, **as directed**:
    - a. Occupancy:
      - 1) Input Device: Occupancy sensor.
      - 2) Output Device: DDC system binary output.
      - 3) Action: Report occupancy and enable occupied temperature set point.
        - a) Occupied Temperature: 75 deg F (24 deg C).
        - b) Unoccupied Temperature: 65 deg F (18 deg C).
    - b. Room Temperature:
      - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
      - 2) Output Device: Pneumatic **OR** Electronic **OR** Electric, **as directed**, control-valve operators.
      - 3) Action: Modulate **OR** Cycle, **as directed**, valve to maintain temperature.
    - c. Display:
      - 1) Room/area served.
      - 2) Room occupied/unoccupied.
      - 3) Room temperature indication.
      - 4) Room temperature set point.
      - 5) Room temperature set point, occupied.
      - 6) Room temperature set point, unoccupied.
      - 7) Control-valve position as percent open.
  17. VAV, Terminal Air Units with Hydronic **OR** Steam, **as directed**, Coils:
    - a. Occupancy:
      - 1) Input Device: Occupancy sensor.
      - 2) Output Device: DDC system binary output.
      - 3) Action: Report occupancy and enable occupied temperature set point.
        - a) Occupied Temperature: 75 deg F (24 deg C).
        - b) Unoccupied Temperature: 65 deg F (18 deg C).

- b. Room Temperature:
      - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
      - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, damper actuators and control-valve operators.
      - 3) Action: Modulate damper and valve to maintain temperature.
        - a) Sequence damper from full open to minimum position, then valve from closed to fully open.
    - c. Display:
      - 1) Room/area served.
      - 2) Room occupied/unoccupied.
      - 3) Room temperature indication.
      - 4) Room temperature set point.
      - 5) Room temperature set point, occupied.
      - 6) Room temperature set point, unoccupied.
      - 7) Air-damper position as percent open.
      - 8) Control-valve position as percent open.
  18. Dual-Duct, VAV, Terminal Air Units:
    - a. Occupancy:
      - 1) Input Device: Occupancy sensor.
      - 2) Output Device: DDC system binary output.
      - 3) Action: Report occupancy and enable occupied temperature set point.
        - a) Occupied Temperature: 75 deg F (24 deg C).
        - b) Unoccupied Temperature: 65 deg F (18 deg C).
    - b. Room Temperature:
      - 1) Input Device: Room thermostat **OR** Electronic temperature sensor, **as directed**.
      - 2) Output Device: Pneumatic **OR** Electronic, **as directed**, damper actuators.
      - 3) Action: Modulate dampers to maintain temperature.
        - a) Sequence when space temperature is below set point: Close VAV damper to minimum position, open hot-deck dampers and close cold-deck dampers, then open VAV damper.
        - b) Sequence when space temperature is above set point: Close VAV damper to minimum position, close hot-deck dampers and open cold-deck dampers, then open VAV damper.
    - c. Display:
      - 1) Room/area served.
      - 2) Room occupied/unoccupied.
      - 3) Room temperature indication.
      - 4) Room temperature set point.
      - 5) Room temperature set point, occupied.
      - 6) Room temperature set point, unoccupied.
      - 7) VAV damper position as percent open.
      - 8) Hot-deck damper position as percent open.
      - 9) Cold-deck damper position as percent open.
  - H. Ventilation Sequences
    1. Combustion-Air, Makeup Unit Control, Electric: Start fan when served appliance burner starts; room thermostat sequences stages of heating.
    2. Combustion-Air, Makeup Unit Control, Hydronic **OR** Steam, **as directed**: Start fan when served appliance burner starts; room thermostat cycles **OR** modulates, **as directed**, control valve.
    3. Gravity Roof Ventilator: Occupancy sensor **OR** Room thermostat, **as directed**, opens dampers.
    4. Exhaust Fan: Occupancy sensor **OR** Interlock with light switch **OR** Room thermostat, **as directed**, cycles fan.
    5. Kitchen Exhaust Fan: Occupancy sensor starts fan and energizes makeup air unit.



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1.2 PRODUCTS (Not Applicable)

1.3 EXECUTION (Not Applicable)

END OF SECTION 23 01 10 91

NOT FOR BID

## SECTION 23 01 10 91a - TESTING, ADJUSTING, AND BALANCING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for testing, adjusting and balancing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Balancing Air Systems:
    - 1) Constant-volume air systems.
    - 2) Dual-duct systems.
    - 3) Variable-air-volume systems.
    - 4) Multizone systems.
    - 5) Induction-unit systems.
  - b. Balancing Hydronic Piping Systems:
    - 1) Constant-flow hydronic systems.
    - 2) Variable-flow hydronic systems.
    - 3) Primary-secondary hydronic systems.

#### C. Definitions

1. AABC: Associated Air Balance Council.
2. NEBB: National Environmental Balancing Bureau.
3. TAB: Testing, adjusting, and balancing.
4. TABB: Testing, Adjusting, and Balancing Bureau.
5. TAB Specialist: An entity engaged to perform TAB Work.

#### D. Submittals

1. LEED Submittal:
  - a. Air-Balance Report for LEED Prerequisite EQ 1: Documentation of work performed for ASHRAE 62.1, Section 7.2.2, "Air Balancing."
2. Strategies and Procedures Plan: Within 30 **OR** 60 **OR** 90, **as directed**, days of Contractor's Notice to Proceed, submit TAB strategies and step-by-step procedures as specified in "Preparation" Article.
3. Certified TAB reports.

#### E. Quality Assurance

1. TAB Contractor Qualifications: Engage a TAB entity certified by AABC **OR** NEBB **OR** TABB **OR** one who meets the requirements necessary for certification, **as directed**.
  - a. TAB Field Supervisor: Employee of the TAB contractor and certified by AABC **OR** NEBB **OR** TABB **OR** one who meets the requirements necessary for certification, **as directed**.
  - b. TAB Technician: Employee of the TAB contractor and who is certified by AABC **OR** NEBB **OR** TABB **OR** one who meets the requirements necessary for certification as a TAB technician, **as directed**.
2. Certify TAB field data reports and perform the following:
  - a. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
  - b. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
3. TAB Report Forms: Use standard TAB contractor's forms approved by the Owner **OR** Commissioning Authority, **as directed**.



4. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

F. Project Conditions

1. Full the Owner Occupancy: the Owner will occupy the site and existing building during entire TAB period. Cooperate with the Owner during TAB operations to minimize conflicts with the Owner's operations.

**OR**

Partial the Owner Occupancy: the Owner may occupy completed areas of building before Final Completion. Cooperate with the Owner during TAB operations to minimize conflicts with the Owner's operations.

1.2 PRODUCTS (Not Applicable)

1.3 EXECUTION

A. Examination

1. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
2. Examine systems for installed balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible.
3. Examine the approved submittals for HVAC systems and equipment.
4. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
5. Examine ceiling plenums and underfloor air plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section(s) "Metal Ducts" OR "Nonmetal Ducts", **as directed**, and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
6. Examine equipment performance data including fan and pump curves.
  - a. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system.
  - b. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," or in SMACNA's "HVAC Systems - Duct Design." Compare results with the design data and installed conditions.
7. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
8. Examine test reports specified in individual system and equipment Sections.
9. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
10. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.
11. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
12. Examine three-way valves for proper installation for their intended function of diverting or mixing fluid flows.
13. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
14. Examine system pumps to ensure absence of entrained air in the suction piping.
15. Examine operating safety interlocks and controls on HVAC equipment.



16. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

B. Preparation

1. Prepare a TAB plan that includes strategies and step-by-step procedures.
2. Complete system-readiness checks and prepare reports. Verify the following:
  - a. Permanent electrical-power wiring is complete.
  - b. Hydronic systems are filled, clean, and free of air.
  - c. Automatic temperature-control systems are operational.
  - d. Equipment and duct access doors are securely closed.
  - e. Balance, smoke, and fire dampers are open.
  - f. Isolating and balancing valves are open and control valves are operational.
  - g. Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.
  - h. Windows and doors can be closed so indicated conditions for system operations can be met.

C. General Procedures For Testing And Balancing

1. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance" **OR** ASHRAE 111 **OR** NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" **OR** SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing", **as directed**, and in this Section.
  - a. Comply with requirements in ASHRAE 62.1, Section 7.2.2, "Air Balancing."
2. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
  - a. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.  
**OR**  
After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories".
  - b. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section "Hvac Insulation".
3. Mark equipment and balancing devices, including damper-control positions, valve position indicators, fan-speed-control levers, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.
4. Take and report testing and balancing measurements in inch-pound (IP) **OR** metric (SI) **OR** inch-pound (IP) and metric (SI), **as directed**, units.

D. General Procedures For Balancing Air Systems

1. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.
2. Prepare schematic diagrams of systems' "as-built" duct layouts.
3. For variable-air-volume systems, develop a plan to simulate diversity.
4. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.
5. Check airflow patterns from the outdoor-air louvers and dampers and the return- and exhaust-air dampers through the supply-fan discharge and mixing dampers.
6. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
7. Verify that motor starters are equipped with properly sized thermal protection.
8. Check dampers for proper position to achieve desired airflow path.
9. Check for airflow blockages.
10. Check condensate drains for proper connections and functioning.
11. Check for proper sealing of air-handling-unit components.
12. Verify that air duct system is sealed as specified in Division 23 Section "Metal Ducts".



#### E. Procedures For Constant-Volume Air Systems

1. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
  - a. Measure total airflow.
    - 1) Where sufficient space in ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow.
  - b. Measure fan static pressures as follows to determine actual static pressure:
    - 1) Measure outlet static pressure as far downstream from the fan as practical and upstream from restrictions in ducts such as elbows and transitions.
    - 2) Measure static pressure directly at the fan outlet or through the flexible connection.
    - 3) Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from the flexible connection, and downstream from duct restrictions.
    - 4) Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.
  - c. Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.
    - 1) Report the cleanliness status of filters and the time static pressures are measured.
  - d. Measure static pressures entering and leaving other devices, such as sound traps, heat-recovery equipment, and air washers, under final balanced conditions.
  - e. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
  - f. Obtain approval from the Owner **OR** Commissioning Authority, **as directed**, for adjustment of fan speed higher or lower than indicated speed. Comply with requirements in Division 21 for air-handling units for adjustment of fans, belts, and pulley sizes to achieve indicated air-handling-unit performance.
  - g. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload will occur. Measure amperage in full-cooling, full-heating, economizer, and any other operating mode to determine the maximum required brake horsepower.
2. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.
  - a. Measure airflow of submain and branch ducts.
    - 1) Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.
  - b. Measure static pressure at a point downstream from the balancing damper, and adjust volume dampers until the proper static pressure is achieved.
  - c. Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
3. Measure air outlets and inlets without making adjustments.
  - a. Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.
4. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
  - a. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
  - b. Adjust patterns of adjustable outlets for proper distribution without drafts.

#### F. Procedures For Dual-Duct Systems

1. Verify that the cooling coil is capable of full-system airflow, and set mixing boxes at full-cold airflow position for fan volume.
  2. Measure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.
    - a. If insufficient static pressure exists, increase airflow at the fan.
  3. Test and adjust the constant-volume mixing boxes as follows:
    - a. Verify both hot and cold operations by adjusting the thermostat and observing changes in air temperature and volume.
    - b. Verify sufficient inlet static pressure before making volume adjustments.
    - c. Adjust mixing boxes to indicated airflows within specified tolerances. Measure airflow by Pitot-tube traverse readings or by measuring static pressure at mixing-box taps if provided by mixing-box manufacturer.
  4. Do not overpressurize ducts.
  5. Remeasure static pressure in both hot and cold ducts at the end of the longest duct run to determine that sufficient static pressure exists to operate controls of mixing boxes and to overcome resistance in the ducts and outlets downstream from mixing boxes.
  6. Adjust variable-air-volume, dual-duct systems in the same way as constant-volume, dual-duct systems; adjust maximum- and minimum-airflow setting of each mixing box.
- G. Procedures For Variable-Air-Volume Systems
1. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
  2. Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
    - a. Set outdoor-air dampers at minimum, and set return- and exhaust-air dampers at a position that simulates full-cooling load.
    - b. Select the terminal unit that is most critical to the supply-fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
    - c. Measure total system airflow. Adjust to within indicated airflow.
    - d. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
    - e. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
      - 1) If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
    - f. Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
      - 1) Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
    - g. Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
    - h. Record final fan-performance data.
  3. Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:



- a. Balance variable-air-volume systems the same as described for constant-volume air systems.
  - b. Set terminal units and supply fan at full-airflow condition.
  - c. Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
  - d. Readjust fan airflow for final maximum readings.
  - e. Measure operating static pressure at the sensor that controls the supply fan if one is installed, and verify operation of the static-pressure controller.
  - f. Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.
  - g. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant-volume air systems.
    - 1) If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.
  - h. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
    - 1) Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
4. Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:
- a. Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced-airflow terminal units so they are distributed evenly among the branch ducts.
  - b. Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.
  - c. Set terminal units at full-airflow condition.
  - d. Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant-volume air systems.
  - e. Adjust terminal units for minimum airflow.
  - f. Measure static pressure at the sensor.
  - g. Measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow. Adjust the fan and balance the return-air ducts and inlets the same as described for constant-volume air systems.
- H. Procedures For Multizone Systems
1. Set unit at maximum airflow through the cooling coil.
  2. Adjust each zone's balancing damper to achieve indicated airflow within the zone.
- I. Procedures For Induction-Unit Systems
1. Balance primary-air risers by measuring static pressure at the nozzles of the top and bottom units of each riser to determine which risers must be throttled. Adjust risers to indicated airflow within specified tolerances.
  2. Adjust each induction unit.
- J. General Procedures For Hydronic Systems
1. Prepare test reports with pertinent design data, and number in sequence starting at pump to end of system. Check the sum of branch-circuit flows against the approved pump flow rate. Correct variations that exceed plus or minus 5 percent.
  2. Prepare schematic diagrams of systems' "as-built" piping layouts.
  3. Prepare hydronic systems for testing and balancing according to the following, in addition to the general preparation procedures specified above:

- a. Open all manual valves for maximum flow.
- b. Check liquid level in expansion tank.
- c. Check makeup water-station pressure gage for adequate pressure for highest vent.
- d. Check flow-control valves for specified sequence of operation, and set at indicated flow.
- e. Set differential-pressure control valves at the specified differential pressure. Do not set at fully closed position when pump is positive-displacement type unless several terminal valves are kept open.
- f. Set system controls so automatic valves are wide open to heat exchangers.
- g. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded.
- h. Check air vents for a forceful liquid flow exiting from vents when manually operated.

K. Procedures For Constant-Flow Hydronic Systems

1. Measure water flow at pumps. Use the following procedures except for positive-displacement pumps:
  - a. Verify impeller size by operating the pump with the discharge valve closed. Read pressure differential across the pump. Convert pressure to head and correct for differences in gage heights. Note the point on manufacturer's pump curve at zero flow and verify that the pump has the intended impeller size.
    - 1) If impeller sizes must be adjusted to achieve pump performance, obtain approval from the Owner **OR** Commissioning Authority, **as directed**, and comply with requirements in Division 23 Section "Hydronic Pumps".
  - b. Check system resistance. With all valves open, read pressure differential across the pump and mark pump manufacturer's head-capacity curve. Adjust pump discharge valve until indicated water flow is achieved.
    - 1) Monitor motor performance during procedures and do not operate motors in overload conditions.
  - c. Verify pump-motor brake horsepower. Calculate the intended brake horsepower for the system based on pump manufacturer's performance data. Compare calculated brake horsepower with nameplate data on the pump motor. Report conditions where actual amperage exceeds motor nameplate amperage.
  - d. Report flow rates that are not within plus or minus 10 percent of design.
2. Measure flow at all automatic flow control valves to verify that valves are functioning as designed.
3. Measure flow at all pressure-independent characterized control valves, with valves in fully open position, to verify that valves are functioning as designed.
4. Set calibrated balancing valves, if installed, at calculated presettings.
5. Measure flow at all stations and adjust, where necessary, to obtain first balance.
  - a. System components that have Cv rating or an accurately cataloged flow-pressure-drop relationship may be used as a flow-indicating device.
6. Measure flow at main balancing station and set main balancing device to achieve flow that is 5 percent greater than indicated flow.
7. Adjust balancing stations to within specified tolerances of indicated flow rate as follows:
  - a. Determine the balancing station with the highest percentage over indicated flow.
  - b. Adjust each station in turn, beginning with the station with the highest percentage over indicated flow and proceeding to the station with the lowest percentage over indicated flow.
  - c. Record settings and mark balancing devices.
8. Measure pump flow rate and make final measurements of pump amperage, voltage, rpm, pump heads, and systems' pressures and temperatures including outdoor-air temperature.
9. Measure the differential-pressure-control-valve settings existing at the conclusion of balancing.
10. Check settings and operation of each safety valve. Record settings.

L. Procedures For Variable-Flow Hydronic Systems

1. Balance systems with automatic two- and three-way control valves by setting systems at maximum flow through heat-exchange terminals and proceed as specified above for hydronic systems.

- M. Procedures For Primary-Secondary Hydronic Systems
1. Balance the primary circuit flow first and then balance the secondary circuits.
- N. Procedures For Steam Systems
1. Measure and record upstream and downstream pressure of each piece of equipment.
  2. Measure and record upstream and downstream steam pressure of pressure-reducing valves.
  3. Check settings and operation of automatic temperature-control valves, self-contained control valves, and pressure-reducing valves. Record final settings.
  4. Check settings and operation of each safety valve. Record settings.
  5. Verify the operation of each steam trap.
- O. Procedures For Heat Exchangers
1. Measure water flow through all circuits.
  2. Adjust water flow to within specified tolerances.
  3. Measure inlet and outlet water temperatures.
  4. Measure inlet steam pressure.
  5. Check settings and operation of safety and relief valves. Record settings.
- P. Procedures For Motors
1. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
    - a. Manufacturer's name, model number, and serial number.
    - b. Motor horsepower rating.
    - c. Motor rpm.
    - d. Efficiency rating.
    - e. Nameplate and measured voltage, each phase.
    - f. Nameplate and measured amperage, each phase.
    - g. Starter thermal-protection-element rating.
  2. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.
- Q. Procedures For Chillers
1. Balance water flow through each evaporator and condenser, **as directed**, to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
    - a. Evaporator-water entering and leaving temperatures, pressure drop, and water flow.
    - b. For water-cooled chillers, condenser-water entering and leaving temperatures, pressure drop, and water flow.
    - c. Evaporator and condenser refrigerant temperatures and pressures, using instruments furnished by chiller manufacturer.
    - d. Power factor if factory-installed instrumentation is furnished for measuring kilowatts.
    - e. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
    - f. Capacity: Calculate in tons of cooling.
    - g. For air-cooled chillers, verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.
- R. Procedures For Cooling Towers
1. Shut off makeup water for the duration of the test, and verify that makeup and blowdown systems are fully operational after tests and before leaving the equipment. Perform the following tests and record the results:
    - a. Measure condenser-water flow to each cell of the cooling tower.
    - b. Measure entering- and leaving-water temperatures.



- c. Measure wet- and dry-bulb temperatures of entering air.
  - d. Measure wet- and dry-bulb temperatures of leaving air.
  - e. Measure condenser-water flow rate recirculating through the cooling tower.
  - f. Measure cooling-tower spray pump discharge pressure.
  - g. Adjust water level and feed rate of makeup water system.
  - h. Measure flow through bypass.
- S. Procedures For Condensing Units
  - 1. Verify proper rotation of fans.
  - 2. Measure entering- and leaving-air temperatures.
  - 3. Record compressor data.
- T. Procedures For Boilers
  - 1. Hydronic Boilers: Measure and record entering- and leaving-water temperatures and water flow.
  - 2. Steam Boilers: Measure and record entering-water temperature and flow and leaving-steam pressure, temperature, and flow.
- U. Procedures For Heat-Transfer Coils
  - 1. Measure, adjust, and record the following data for each water coil:
    - a. Entering- and leaving-water temperature.
    - b. Water flow rate.
    - c. Water pressure drop.
    - d. Dry-bulb temperature of entering and leaving air.
    - e. Wet-bulb temperature of entering and leaving air for cooling coils.
    - f. Airflow.
    - g. Air pressure drop.
  - 2. Measure, adjust, and record the following data for each electric heating coil:
    - a. Nameplate data.
    - b. Airflow.
    - c. Entering- and leaving-air temperature at full load.
    - d. Voltage and amperage input of each phase at full load and at each incremental stage.
    - e. Calculated kilowatt at full load.
    - f. Fuse or circuit-breaker rating for overload protection.
  - 3. Measure, adjust, and record the following data for each steam coil:
    - a. Dry-bulb temperature of entering and leaving air.
    - b. Airflow.
    - c. Air pressure drop.
    - d. Inlet steam pressure.
  - 4. Measure, adjust, and record the following data for each refrigerant coil:
    - a. Dry-bulb temperature of entering and leaving air.
    - b. Wet-bulb temperature of entering and leaving air.
    - c. Airflow.
    - d. Air pressure drop.
    - e. Refrigerant suction pressure and temperature.
- V. Procedures For Testing, Adjusting, And Balancing Existing Systems
  - 1. Perform a preconstruction inspection of existing equipment that is to remain and be reused.
    - a. Measure and record the operating speed, airflow, and static pressure of each fan.
    - b. Measure motor voltage and amperage. Compare the values to motor nameplate information.
    - c. Check the refrigerant charge.
    - d. Check the condition of filters.
    - e. Check the condition of coils.
    - f. Check the operation of the drain pan and condensate-drain trap.
    - g. Check bearings and other lubricated parts for proper lubrication.

- h. Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.
2. Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished. Verify the following:
  - a. New filters are installed.
  - b. Coils are clean and fins combed.
  - c. Drain pans are clean.
  - d. Fans are clean.
  - e. Bearings and other parts are properly lubricated.
  - f. Deficiencies noted in the preconstruction report are corrected.
3. Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work.
  - a. Compare the indicated airflow of the renovated work to the measured fan airflows, and determine the new fan speed and the face velocity of filters and coils.
  - b. Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are within the acceptable limits defined by equipment manufacturer.
  - c. If calculations increase or decrease the air flow rates and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated rates. If increase or decrease is 5 percent or less, equipment adjustments are not required.
  - d. Balance each air outlet.

W. Tolerances

- X. Set HVAC system's air flow rates and water flow rates within the following tolerances:
- a. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
  - b. Air Outlets and Inlets: Plus or minus 10 percent.
  - c. Heating-Water Flow Rate: Plus or minus 10 percent.
  - d. Cooling-Water Flow Rate: Plus or minus 10 percent.

Y. Reporting

1. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
2. Status Reports: Prepare weekly **OR** biweekly **OR** monthly, **as directed**, progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

Z. Final Report

1. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
  - a. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
  - b. Include a list of instruments used for procedures, along with proof of calibration.
2. Final Report Contents: In addition to certified field-report data, include the following:
  - a. Pump curves.
  - b. Fan curves.
  - c. Manufacturers' test data.
  - d. Field test reports prepared by system and equipment installers.
  - e. Other information relative to equipment performance; do not include Shop Drawings and product data.
3. General Report Data: In addition to form titles and entries, include the following data:

- a. Title page.
- b. Name and address of the TAB contractor.
- c. Project name.
- d. Project location.
- e. Architect's name and address.
- f. Engineer's name and address.
- g. Contractor's name and address.
- h. Report date.
- i. Signature of TAB supervisor who certifies the report.
- j. Table of Contents with the total number of pages defined for each section of the report.  
Number each page in the report.
- k. Summary of contents including the following:
  - 1) Indicated versus final performance.
  - 2) Notable characteristics of systems.
  - 3) Description of system operation sequence if it varies from the Contract Documents.
- l. Nomenclature sheets for each item of equipment.
- m. Data for terminal units, including manufacturer's name, type, size, and fittings.
- n. Notes to explain why certain final data in the body of reports vary from indicated values.
- o. Test conditions for fans and pump performance forms including the following:
  - 1) Settings for outdoor-, return-, and exhaust-air dampers.
  - 2) Conditions of filters.
  - 3) Cooling coil, wet- and dry-bulb conditions.
  - 4) Face and bypass damper settings at coils.
  - 5) Fan drive settings including settings and percentage of maximum pitch diameter.
  - 6) Inlet vane settings for variable-air-volume systems.
  - 7) Settings for supply-air, static-pressure controller.
  - 8) Other system operating conditions that affect performance.
4. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
  - a. Quantities of outdoor, supply, return, and exhaust airflows.
  - b. Water and steam flow rates.
  - c. Duct, outlet, and inlet sizes.
  - d. Pipe and valve sizes and locations.
  - e. Terminal units.
  - f. Balancing stations.
  - g. Position of balancing devices.
5. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
  - a. Unit Data:
    - 1) Unit identification.
    - 2) Location.
    - 3) Make and type.
    - 4) Model number and unit size.
    - 5) Manufacturer's serial number.
    - 6) Unit arrangement and class.
    - 7) Discharge arrangement.
    - 8) Sheave make, size in inches (mm), and bore.
    - 9) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
    - 10) Number, make, and size of belts.
    - 11) Number, type, and size of filters.
  - b. Motor Data:
    - 1) Motor make, and frame type and size.
    - 2) Horsepower and rpm.
    - 3) Volts, phase, and hertz.
    - 4) Full-load amperage and service factor.
    - 5) Sheave make, size in inches (mm), and bore.
    - 6) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).

- c. Test Data (Indicated and Actual Values):
- 1) Total air flow rate in **cfm** (L/s).
  - 2) Total system static pressure in **inches wg** (Pa).
  - 3) Fan rpm.
  - 4) Discharge static pressure in **inches wg** (Pa).
  - 5) Filter static-pressure differential in **inches wg** (Pa).
  - 6) Preheat-coil static-pressure differential in **inches wg** (Pa).
  - 7) Cooling-coil static-pressure differential in **inches wg** (Pa).
  - 8) Heating-coil static-pressure differential in **inches wg** (Pa).
  - 9) Outdoor airflow in **cfm** (L/s).
  - 10) Return airflow in **cfm** (L/s).
  - 11) Outdoor-air damper position.
  - 12) Return-air damper position.
  - 13) Vortex damper position.
6. Apparatus-Coil Test Reports:
- a. Coil Data:
- 1) System identification.
  - 2) Location.
  - 3) Coil type.
  - 4) Number of rows.
  - 5) Fin spacing in **fins per inch** (mm) o.c.
  - 6) Make and model number.
  - 7) Face area in **sq. ft.** (sq. m).
  - 8) Tube size in **NPS** (DN).
  - 9) Tube and fin materials.
  - 10) Circuiting arrangement.
- b. Test Data (Indicated and Actual Values):
- 1) Air flow rate in **cfm** (L/s).
  - 2) Average face velocity in **fpm** (m/s).
  - 3) Air pressure drop in **inches wg** (Pa).
  - 4) Outdoor-air, wet- and dry-bulb temperatures in **deg F** (deg C).
  - 5) Return-air, wet- and dry-bulb temperatures in **deg F** (deg C).
  - 6) Entering-air, wet- and dry-bulb temperatures in **deg F** (deg C).
  - 7) Leaving-air, wet- and dry-bulb temperatures in **deg F** (deg C).
  - 8) Water flow rate in **gpm** (L/s).
  - 9) Water pressure differential in **feet of head or psig** (kPa).
  - 10) Entering-water temperature in **deg F** (deg C).
  - 11) Leaving-water temperature in **deg F** (deg C).
  - 12) Refrigerant expansion valve and refrigerant types.
  - 13) Refrigerant suction pressure in **psig** (kPa).
  - 14) Refrigerant suction temperature in **deg F** (deg C).
  - 15) Inlet steam pressure in **psig** (kPa).
7. Gas- and Oil-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:
- a. Unit Data:
- 1) System identification.
  - 2) Location.
  - 3) Make and type.
  - 4) Model number and unit size.
  - 5) Manufacturer's serial number.
  - 6) Fuel type in input data.
  - 7) Output capacity in **Btu/h** (kW).
  - 8) Ignition type.
  - 9) Burner-control types.
  - 10) Motor horsepower and rpm.

- 11) Motor volts, phase, and hertz.
- 12) Motor full-load amperage and service factor.
- 13) Sheave make, size in inches (mm), and bore.
- 14) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
- b. Test Data (Indicated and Actual Values):
  - 1) Total air flow rate in cfm (L/s).
  - 2) Entering-air temperature in deg F (deg C).
  - 3) Leaving-air temperature in deg F (deg C).
  - 4) Air temperature differential in deg F (deg C).
  - 5) Entering-air static pressure in inches wg (Pa).
  - 6) Leaving-air static pressure in inches wg (Pa).
  - 7) Air static-pressure differential in inches wg (Pa).
  - 8) Low-fire fuel input in Btu/h (kW).
  - 9) High-fire fuel input in Btu/h (kW).
  - 10) Manifold pressure in psig (kPa).
  - 11) High-temperature-limit setting in deg F (deg C).
  - 12) Operating set point in Btu/h (kW).
  - 13) Motor voltage at each connection.
  - 14) Motor amperage for each phase.
  - 15) Heating value of fuel in Btu/h (kW).
8. Electric-Coil Test Reports: For electric furnaces, duct coils, and electric coils installed in central-station air-handling units, include the following:
  - a. Unit Data:
    - 1) System identification.
    - 2) Location.
    - 3) Coil identification.
    - 4) Capacity in Btu/h (kW).
    - 5) Number of stages.
    - 6) Connected volts, phase, and hertz.
    - 7) Rated amperage.
    - 8) Air flow rate in cfm (L/s).
    - 9) Face area in sq. ft. (sq. m).
    - 10) Minimum face velocity in fpm (m/s).
  - b. Test Data (Indicated and Actual Values):
    - 1) Heat output in Btu/h (kW).
    - 2) Air flow rate in cfm (L/s).
    - 3) Air velocity in fpm (m/s).
    - 4) Entering-air temperature in deg F (deg C).
    - 5) Leaving-air temperature in deg F (deg C).
    - 6) Voltage at each connection.
    - 7) Amperage for each phase.
9. Fan Test Reports: For supply, return, and exhaust fans, include the following:
  - a. Fan Data:
    - 1) System identification.
    - 2) Location.
    - 3) Make and type.
    - 4) Model number and size.
    - 5) Manufacturer's serial number.
    - 6) Arrangement and class.
    - 7) Sheave make, size in inches (mm), and bore.
    - 8) Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
  - b. Motor Data:
    - 1) Motor make, and frame type and size.
    - 2) Horsepower and rpm.
    - 3) Volts, phase, and hertz.
    - 4) Full-load amperage and service factor.

- 5) Sheave make, size in **inches (mm)**, and bore.
- 6) Center-to-center dimensions of sheave, and amount of adjustments in **inches (mm)**.
- 7) Number, make, and size of belts.
- c. Test Data (Indicated and Actual Values):
  - 1) Total airflow rate in **cfm (L/s)**.
  - 2) Total system static pressure in **inches wg (Pa)**.
  - 3) Fan rpm.
  - 4) Discharge static pressure in **inches wg (Pa)**.
  - 5) Suction static pressure in **inches wg (Pa)**.
10. Round, Flat-Oval, and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
  - a. Report Data:
    - 1) System and air-handling-unit number.
    - 2) Location and zone.
    - 3) Traverse air temperature in **deg F (deg C)**.
    - 4) Duct static pressure in **inches wg (Pa)**.
    - 5) Duct size in **inches (mm)**.
    - 6) Duct area in **sq. ft. (sq. m)**.
    - 7) Indicated air flow rate in **cfm (L/s)**.
    - 8) Indicated velocity in **fpm (m/s)**.
    - 9) Actual air flow rate in **cfm (L/s)**.
    - 10) Actual average velocity in **fpm (m/s)**.
    - 11) Barometric pressure in **psig (Pa)**.
11. Air-Terminal-Device Reports:
  - a. Unit Data:
    - 1) System and air-handling unit identification.
    - 2) Location and zone.
    - 3) Apparatus used for test.
    - 4) Area served.
    - 5) Make.
    - 6) Number from system diagram.
    - 7) Type and model number.
    - 8) Size.
    - 9) Effective area in **sq. ft. (sq. m)**.
  - b. Test Data (Indicated and Actual Values):
    - 1) Air flow rate in **cfm (L/s)**.
    - 2) Air velocity in **fpm (m/s)**.
    - 3) Preliminary air flow rate as needed in **cfm (L/s)**.
    - 4) Preliminary velocity as needed in **fpm (m/s)**.
    - 5) Final air flow rate in **cfm (L/s)**.
    - 6) Final velocity in **fpm (m/s)**.
    - 7) Space temperature in **deg F (deg C)**.
12. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:
  - a. Unit Data:
    - 1) System and air-handling-unit identification.
    - 2) Location and zone.
    - 3) Room or riser served.
    - 4) Coil make and size.
    - 5) Flowmeter type.
  - b. Test Data (Indicated and Actual Values):
    - 1) Air flow rate in **cfm (L/s)**.
    - 2) Entering-water temperature in **deg F (deg C)**.
    - 3) Leaving-water temperature in **deg F (deg C)**.
    - 4) Water pressure drop in **feet of head or psig (kPa)**.
    - 5) Entering-air temperature in **deg F (deg C)**.



- 6) Leaving-air temperature in **deg F (deg C)**.
13. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:
  - a. Unit Data:
    - 1) Unit identification.
    - 2) Location.
    - 3) Service.
    - 4) Make and size.
    - 5) Model number and serial number.
    - 6) Water flow rate in **gpm (L/s)**.
    - 7) Water pressure differential in **feet of head or psig (kPa)**.
    - 8) Required net positive suction head in **feet of head or psig (kPa)**.
    - 9) Pump rpm.
    - 10) Impeller diameter in **inches (mm)**.
    - 11) Motor make and frame size.
    - 12) Motor horsepower and rpm.
    - 13) Voltage at each connection.
    - 14) Amperage for each phase.
    - 15) Full-load amperage and service factor.
    - 16) Seal type.
  - b. Test Data (Indicated and Actual Values):
    - 1) Static head in **feet of head or psig (kPa)**.
    - 2) Pump shutoff pressure in **feet of head or psig (kPa)**.
    - 3) Actual impeller size in **inches (mm)**.
    - 4) Full-open flow rate in **gpm (L/s)**.
    - 5) Full-open pressure in **feet of head or psig (kPa)**.
    - 6) Final discharge pressure in **feet of head or psig (kPa)**.
    - 7) Final suction pressure in **feet of head or psig (kPa)**.
    - 8) Final total pressure in **feet of head or psig (kPa)**.
    - 9) Final water flow rate in **gpm (L/s)**.
    - 10) Voltage at each connection.
    - 11) Amperage for each phase.
14. Instrument Calibration Reports:
  - a. Report Data:
    - 1) Instrument type and make.
    - 2) Serial number.
    - 3) Application.
    - 4) Dates of use.
    - 5) Dates of calibration.
- AA. Inspections
  1. Initial Inspection:
    - a. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
    - b. Check the following for each system:
      - 1) Measure airflow of at least 10 percent of air outlets.
      - 2) Measure water flow of at least 5 percent of terminals.
      - 3) Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
      - 4) Verify that balancing devices are marked with final balance position.
      - 5) Note deviations from the Contract Documents in the final report.
  2. Final Inspection:
    - a. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by the Owner **OR** Commissioning Authority, **as directed**.



- b. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of the Owner **OR** Commissioning Authority, **as directed**.
- c. the Owner **OR** Commissioning Authority, **as directed**, shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
- d. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
- e. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
3. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
  - a. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
  - b. If the second final inspection also fails, the Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
4. Prepare test and inspection reports.

BB. Additional Tests

1. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
2. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 01 10 91a



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Task	Specification	Specification Description
23 01 20 91	23 01 10 91	Sequence Of Operation
23 01 20 91	23 01 10 91a	Testing, Adjusting, And Balancing

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## SECTION 23 01 30 51 - AIR DUCT CLEANING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC air-distribution system cleaning. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes cleaning HVAC air-distribution equipment, ducts, plenums, and system components.

#### C. Definitions

1. ASCS: Air systems cleaning specialist.
2. NADCA: National Air Duct Cleaners Association.

#### D. Submittals

1. Qualification Data: For an ASCS.
2. Strategies and procedures plan.
3. Cleanliness verification report.

#### E. Quality Assurance

1. ASCS Qualifications: A certified member of NADCA **OR** one who meets the requirements necessary for certification, **as directed**.
  - a. Certification: Employ an ASCS certified by NADCA **OR** one who meets the requirements necessary for certification, **as directed**, on a full-time basis.
  - b. Supervisor Qualifications: Certified as an ASCS by NADCA **OR** one who meets the requirements necessary for certification, **as directed**.
2. UL Compliance: Comply with UL 181 and UL 181A for fibrous-glass ducts.
3. Cleaning Conference: Conduct conference at Project site.

### 1.2 PRODUCTS (Not Used)

### 1.3 EXECUTION

#### A. Examination

1. Examine HVAC air-distribution equipment, ducts, plenums, and system components to determine appropriate methods, tools, and equipment required for performance of the Work.
2. Perform "Project Evaluation and Recommendation" according to NADCA ACR 2006.
3. Prepare written report listing conditions detrimental to performance of the Work.
4. Proceed with work only after unsatisfactory conditions have been corrected.

#### B. Preparation

1. Prepare a written plan that includes strategies and step-by-step procedures. At a minimum, include the following:
  - a. Supervisor contact information.
  - b. Work schedule including location, times, and impact on occupied areas.
  - c. Methods and materials planned for each HVAC component type.
  - d. Required support from other trades.
  - e. Equipment and material storage requirements.



- f. Exhaust equipment setup locations.
2. Use the existing service openings, as required for proper cleaning, at various points of the HVAC system for physical and mechanical entry and for inspection.
3. Comply with NADCA ACR 2006, "Guidelines for Constructing Service Openings in HVAC Systems" Section.

C. Cleaning

1. Comply with NADCA ACR 2006.
2. Remove visible surface contaminants and deposits from within the HVAC system.
3. Systems and Components to Be Cleaned:
  - a. Air devices for supply and return air.
  - b. Air-terminal units.
  - c. Ductwork:
    - 1) Supply-air ducts, including turning vanes and reheat coils, to the air-handling unit.
    - 2) Return-air ducts to the air-handling unit.
    - 3) Exhaust-air ducts.
  - d. Air-Handling Units:
    - 1) Interior surfaces of the unit casing.
    - 2) Coil surfaces compartment.
    - 3) Condensate drain pans.
    - 4) Fans, fan blades, and fan housings.
  - e. Filters and filter housings.
4. Collect debris removed during cleaning. Ensure that debris is not dispersed outside the HVAC system during the cleaning process.
5. Particulate Collection:
  - a. For particulate collection equipment, include adequate filtration to contain debris removed. Locate equipment downwind and away from all air intakes and other points of entry into the building.
  - b. HEPA filtration with 99.97 percent collection efficiency for particles sized 0.3 micrometer or larger shall be used where the particulate collection equipment is exhausting inside the building.
6. Control odors and mist vapors during the cleaning and restoration process.
7. Mark the position of manual volume dampers and air-directional mechanical devices inside the system prior to cleaning. Restore them to their marked position on completion of cleaning.
8. System components shall be cleaned so that all HVAC system components are visibly clean. On completion, all components must be returned to those settings recorded just prior to cleaning operations.
9. Clean all air-distribution devices, registers, grilles, and diffusers.
10. Clean visible surface contamination deposits according to NADCA ACR 2006 and the following:
  - a. Clean air-handling units, airstream surfaces, components, condensate collectors, and drains.
  - b. Ensure that a suitable operative drainage system is in place prior to beginning wash-down procedures.
  - c. Clean evaporator coils, reheat coils, and other airstream components.
11. Duct Systems:
  - a. Create service openings in the HVAC system as necessary to accommodate cleaning.
  - b. Mechanically clean duct systems specified to remove all visible contaminants so that the systems are capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
12. Debris removed from the HVAC system shall be disposed of according to applicable Federal, state, and local requirements.
13. Mechanical Cleaning Methodology:
  - a. Source-Removal Cleaning Methods: The HVAC system shall be cleaned using source-removal mechanical cleaning methods designed to extract contaminants from within the HVAC system and to safely remove these contaminants from the facility. No cleaning



method, or combination of methods, shall be used that could potentially damage components of the HVAC system or negatively alter the integrity of the system.

- 1) Use continuously operating vacuum-collection devices to keep each section being cleaned under negative pressure.
- 2) Cleaning methods that require mechanical agitation devices to dislodge debris that is adhered to interior surfaces of HVAC system components shall be equipped to safely remove these devices. Cleaning methods shall not damage the integrity of HVAC system components or damage porous surface materials such as duct and plenum liners.
- b. Cleaning Mineral-Fiber Insulation Components:
  - 1) Fibrous-glass thermal or acoustical insulation elements present in equipment or ductwork shall be thoroughly cleaned with HEPA vacuuming equipment while the HVAC system is under constant negative pressure and shall not be permitted to get wet according to NADCA ACR 2006.
  - 2) Cleaning methods used shall not cause damage to fibrous-glass components and will render the system capable of passing the HVAC System Cleanliness Tests (see NADCA ACR 2006).
  - 3) Fibrous materials that become wet shall be discarded and replaced.
14. Coil Cleaning:
  - a. Measure static-pressure differential across each coil.
  - b. See NADCA ACR 2006, "Coil Surface Cleaning" Section. Type 1, or Type 1 and Type 2, cleaning methods shall be used to render the coil visibly clean and capable of passing Coil Cleaning Verification (see applicable NADCA ACR 2006).
  - c. Coil drain pans shall be subject to NADCA ACR 2006, "Non-Porous Surfaces Cleaning Verification." Ensure that condensate drain pans are operational.
  - d. Electric-resistance coils shall be de-energized, locked out, and tagged before cleaning.
  - e. Cleaning methods shall not cause any appreciable damage to, cause displacement of, inhibit heat transfer, or cause erosion of the coil surface or fins, and shall comply with coil manufacturer's written recommendations when available.
  - f. Rinse thoroughly with clean water to remove any latent residues.
15. Antimicrobial Agents, Coatings, and Sanitizers:
  - a. Apply antimicrobial agents, coatings, and sanitizers if active fungal growth is reasonably suspected or where unacceptable levels of fungal contamination have been verified. Apply antimicrobial agents and coatings according to manufacturer's written recommendations and EPA registration listing after the removal of surface deposits and debris.
  - b. When used, antimicrobial treatments, coatings, and sanitizers shall be applied after the system is rendered clean.
  - c. Apply antimicrobial agents, coatings, and sanitizers directly onto surfaces of interior ductwork. Fogging is prohibited.
  - d. Sanitizing agent products shall be registered by the EPA as specifically intended for use in HVAC systems and ductwork.
- D. Cleanliness Verification
  1. Verify cleanliness according to NADCA ACR 2006, "Verification of HVAC System Cleanliness" Section.
  2. Verify HVAC system cleanliness after mechanical cleaning and before applying any treatment or introducing any treatment-related substance to the HVAC system, including biocidal agents, coatings, and sanitizers.
  3. Perform visual inspection for cleanliness. If no contaminants are evident through visual inspection, the HVAC system shall be considered clean. If visible contaminants are evident through visual inspection, those portions of the system where contaminants are visible shall be re-cleaned and subjected to re-inspection for cleanliness.
  4. Additional Verification:
    - a. Perform surface comparison testing or NADCA vacuum test.
    - b. Conduct NADCA vacuum gravimetric test analysis for nonporous surfaces.
  5. Verification of Coil Cleaning:

- a. Measure static-pressure differential across each coil.
- b. Coil will be considered clean if cleaning restored the coil static-pressure differential within 10 percent of <Insert inches wg (Pa)>, the differential measured when the coil was first installed.

**OR**

Coil will be considered clean if the coil is free of foreign matter and chemical residue, based on a thorough visual inspection.

6. Prepare a written cleanliness verification report. At a minimum, include the following:
  - a. Written documentation of the success of the cleaning.
  - b. Site inspection reports, initialed by supervisor, including notation on areas of inspection, as verified through visual inspection.
  - c. Surface comparison test results if required.
  - d. Gravimetric analysis (nonporous surfaces only).
  - e. System areas found to be damaged.
7. Photographic Documentation: Comply with requirements listed in Scope of Work.

**E. Restoration**

1. Restore and repair HVAC air-distribution equipment, ducts, plenums, and components according to NADCA ACR 2006, "Restoration and Repair of Mechanical Systems" Section.
2. Restore service openings capable of future reopening. Comply with requirements in Division 23 Section "Metal Ducts". Include location of service openings in Project closeout report.
3. Replace fibrous-glass materials that cannot be restored by cleaning or resurfacing. Comply with requirements in Division 23 Section(s) "Metal Ducts" AND "Nonmetal Ducts"
4. Replace damaged insulation according to Division 23 Section "Hvac Insulation",
5. Ensure that closures do not hinder or alter airflow.
6. New closure materials, including insulation, shall match opened materials and shall have removable closure panels fitted with gaskets and fasteners.
7. Reseal fibrous-glass ducts. Comply with requirements in Division 23 Section "Nonmetal Ducts".

END OF SECTION 23 01 30 51



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Task	Specification	Specification Description
23 01 30 51	23 01 10 91	Sequence Of Operation
23 01 30 51	23 01 10 91a	Testing, Adjusting, And Balancing

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## SECTION 23 01 50 61 - CAST-IRON BOILERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for cast-iron boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged cast-iron boilers, trim, and accessories for generating hot water or steam with the following configurations and burners:
  - a. Factory and Field assembled.
  - b. Atmospheric gas, Sealed-combustion, gas, Forced-draft, gas, Oil, and Combination gas and oil burner.

#### C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
  - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
    - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    - 2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
  - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
5. I=B=R Compliance: Boilers shall be tested and rated according to HI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.
6. UL Compliance: Test boilers for compliance with UL 726, "Oil-Fired Boiler Assemblies **OR** UL 726, "Oil-Fired Boiler Assemblies," and UL 795, "Commercial-Industrial Gas Heating



Equipment **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace controls and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Controls: Two years from date of Final Completion.
  - b. Warranty Period for Heat Exchangers: Five **OR** 10 **OR** 20, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units

1. Description: Factory fabricated and assembled **OR** field assembled, **as directed**.
  - a. Cast-iron sections shall be sealed pressure tight and held together with tie rods set on an insulated steel base, **as directed**; including insulated jacket and flue-gas vent connection.  
**OR**  
Ship cast-iron sections disassembled with all materials and equipment, including seals, tie rods, and insulated jacket and flue-gas vent connection for field assembly.
2. Cast-Iron Section Design:
  - a. Configuration: Wet base **OR** back **OR** leg, **as directed**.
  - b. Number of Passes: Single **OR** Multiple, **as directed**.
  - c. Sectional Joints: High-temperature sealant to seal flue-gas passages not in contact with heating medium, tapered cast-iron push nipples, **OR** O-ring gaskets, **OR** fiber roping, **as directed**, and held together with tie rods.
  - d. Drain and blowdown tappings.
  - e. Return injection tube to equalize water flow to all sections.
  - f. Crown inspection tappings with brass plugs.
  - g. Built-in air separator.
3. Combustion Chamber: Equipped with ceramic-fiber target wall **OR** refractory **OR** insulation, **as directed**, and flame observation ports, front and back.
4. Casing:
  - a. Jacket: Sheet metal **OR** Galvanized sheet metal, **as directed**, with snap-in or interlocking closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
  - b. Insulation: Minimum ~~1-inch- (25-mm-)~~ **OR** ~~2-inch- (50-mm-)~~, **as directed**, thick, mineral-fiber insulation surrounding the heat exchanger.
  - c. Combustion Chamber Access: Refractory lined, hinged, front.
  - d. Access: For cleaning between cast-iron sections.
  - e. Draft Hood: Flue canopy and top **OR** rear, **as directed**, flue connection shall be constructed of aluminized **OR** stainless, **as directed**, steel containing adjustable outlet damper assembly.
  - f. Insulated base constructed of aluminized steel to permit boiler to be installed on combustible floor.
  - g. Mounting Frame: Steel rails to mount assembled boiler package on concrete base.
    - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
  - h. Control Cabinet: Sheet metal casing shall cover all controls, gas train, and burner.
5. Draft Diverter: Steel assembly integral with boiler casing **OR** Separate galvanized-steel assembly, **as directed**.

B. Burner: For Atmospheric Gas Burners.

1. Burner Tubes and Orifices: Stainless steel **OR** Cast iron, **as directed**, for natural **OR** propane, **as directed**, gas.
  2. Gas Train: Control devices and full-modulation **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.  
**OR**  
Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
  3. Pilot: Standing **OR** Intermittent-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
- C. Burner: For Residential-Size Boilers With Sealed-Combustion Burners.
1. Burner Tubes and Orifices: Stainless steel **OR** Cast iron, **as directed**, for natural **OR** propane, **as directed**, gas.
  2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  3. Gas Train: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
  4. Pilot: Standing **OR** Intermittent-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
- D. Burner: For Forced-Draft Burners.
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for natural **OR** propane, **as directed**, gas.
  2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  3. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
  4. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
  5. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
    - a. Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
- E. Burner: For Oil Burners.
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil.
  2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  3. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
    - a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
    - b. Oil Piping Specialties:
      - 1) Suction-line, manual, gate valve.
      - 2) Removable-mesh oil strainer.
      - 3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.





- 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
    - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
  4. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid using cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
  5. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
    - a. Maximum Oxides of Nitrogen Emissions: 30 ppm.
- F. Burner: For Combination Gas And Oil Burners.
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and natural **OR** propane, **as directed**, gas.
  2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  3. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
    - a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
    - b. Oil Piping Specialties:
      - 1) Suction-line, manual, gate valve.
      - 2) Removable-mesh oil strainer.
      - 3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
      - 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
      - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
  4. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
  5. Gas Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
  6. Oil Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
  7. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
    - a. Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
- G. Trim: For Hot-Water Boilers.
1. Include devices sized to comply with ANSI B31.9, "Building Services Piping."
  2. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
  3. Safety Relief Valve: ASME rated.
  4. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
  5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
  6. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
  7. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of cast-iron sections and sealed with fiber gasket.
    - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
    - b. Tappings NPS 2-1/2 (DN 65) and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

- H. Trim: For Steam Boilers.
1. Include devices sized to comply with ANSI B31.9, "Building Services Piping."
  2. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
  3. Safety Relief Valve:
    - a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
    - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
      - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
  4. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage shall have normal operating pressure about 50 percent of full range.
  5. Water Column: Minimum **12-inch (300-mm)** glass gage with shutoff cocks.
  6. Drain Valves: Minimum **NPS 3/4 (DN 20)** or nozzle size with hose-end connection.
  7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle.
  8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size as or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
  9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
  10. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of cast-iron sections and sealed with fiber gasket.
    - a. Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
    - b. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
- I. Controls
1. Refer to Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Boiler operating controls shall include the following devices and features:
    - a. Control transformer.
    - b. Set-Point Adjust: Set points shall be adjustable.
    - c. Operating Pressure Control for Steam Boilers: Factory wired and mounted to cycle burner.
    - d. Low-Water Cutoff and Pump Control for Steam Boilers: Cycle feedwater pump(s) for makeup water control.
    - e. Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.  
**OR**  
Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At **0 deg F (minus 17 deg C)** outside-air temperature, set supply-water temperature at **200 deg F (93 deg C)**; at **60 deg F (15 deg C)** outside-air temperature, set supply-water temperature at **140 deg F (60 deg C)**.
    - f. Sequence of Operation for Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
      - 1) Include automatic, alternating-firing sequence for multiple boilers.
  2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
    - a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature **OR** pressure, **as directed**.



- b. Low-Water Cutoff Switch: Electronic for hot-water boilers or Float and electronic for steam boilers probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
- c. Blocked Vent Safety Switch for Atmospheric Burners: Manual-reset switch factory mounted on draft diverter.
- d. Rollout Safety Switch for Atmospheric Burners: Factory mounted on boiler combustion chamber.
- e. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- 3. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
  - a. Hardwired Points:
    - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
    - 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
  - b. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

#### J. Electrical Power

- 1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22..
- 2. Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
  - a. House in NEMA 250, Type 1 enclosure.
  - b. Wiring shall be numbered and color-coded to match wiring diagram.
  - c. Install factory wiring outside of an enclosure in a metal raceway.
  - d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
  - e. Provide branch power circuit to each motor and to controls with disconnect switch or circuit breaker, **as directed**.
  - f. Provide each motor with overcurrent protection.

#### K. Source Quality Control

- 1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
- 2. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- 3. Allow the Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

### 1.3 EXECUTION

#### A. Boiler Installation

- 1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac" and concrete materials and installation requirements are specified in Division 31..
- 2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of **0.25 inch (6.35 mm)**. Vibration isolation devices and installation requirements are

- specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install gas-fired boilers according to NFPA 54.
  4. Install oil-fired boilers according to NFPA 31.
  5. Assemble boiler sections in sequence and seal between each section if boiler is not delivered fully assembled.
  6. Assemble and install boiler trim.
  7. Install electrical devices furnished with boiler but not specified to be factory mounted.
  8. Install control wiring to field-mounted electrical devices.
- B. Connections
1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to boiler to allow service and maintenance.
  3. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
  4. Connect oil piping full size to burner inlet with shutoff valve and union.
  5. Connect hot-water piping to supply- and return-boiler tapplings with shutoff valve and union or flange at each connection.
  6. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tapplings with shutoff valve and union or flange at each connection.
  7. Install piping from safety relief valves to nearest floor drain, for hot-water boilers.
  8. Install piping from safety valves to drip-pan elbow and to nearest floor drain, for steam boilers.
  9. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
  10. Connect breeching full size to boiler outlet. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for venting materials.
  11. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for recirculation duct materials.
  12. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  13. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  2. Tests and Inspections:
    - a. Perform installation and startup checks according to manufacturer's written instructions.
    - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
    - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
    - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      - 1) Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
      - 2) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature **OR** steam pressure, **as directed**.
      - 3) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  3. Remove and replace malfunctioning units and retest as specified above.
  4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.



5. Performance Tests, **as directed**:

- a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
- b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
- c. Perform field performance tests to determine capacity and efficiency of boilers.
  - 1) For dual-fuel boilers, perform tests for each fuel.
  - 2) Test for full capacity.
  - 3) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
- d. Repeat tests until results comply with requirements indicated.
- e. Provide analysis equipment required to determine performance.
- f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
- g. Notify the Owner in advance of test dates.
- h. Document test results in a report and submit to the Owner.

D. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 23 01 50 61



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Task	Specification	Specification Description
23 01 50 61	01 22 16 00	No Specification Required
23 01 50 61	22 11 16 00c	Hydronic Piping

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## SECTION 23 01 60 71 - CONDENSING UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for condensing units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes air-cooled and water-cooled condensing units.

#### C. Submittals

1. Product Data: For each condensing unit, include rated capacities, operating characteristics, furnished specialties, and accessories. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Shop Drawings: Signed and sealed by a qualified professional engineer.
  - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.
  - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment.
  - c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that condensing units, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.
7. LEED Submittal:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Code for Mechanical Refrigeration."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. ASME Compliance: Fabricate and label water-cooled condensing units to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
  - a. Failures include, but are not limited to, the following:
    - 1) Compressor failure.
    - 2) Condenser coil leak.



- b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Final Completion.
- c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Final Completion.
- d. Warranty Period (Condenser Coil Only): Five years from date of Final Completion.

## 1.2 PRODUCTS

### A. Condensing Units, Air Cooled, **1 To 5 Tons (3.5 TO 17.6 kW)**

1. Description: Factory assembled and tested, consisting of compressor, condenser coil, fan, motors, refrigerant reservoir, and operating controls.
2. Compressor: Scroll, hermetically sealed, with rubber vibration isolators.
  - a. Motor: Single **OR** Two, **as directed**, speed, and includes thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
  - b. Two-Speed Compressor: Include manual-reset, high-pressure switch and automatic-reset, low-pressure switch.
  - c. Accumulator: Suction tube.
  - d. Refrigerant Charge: R-407C **OR** R-410A, **as directed**.
3. Condenser Coil: Seamless copper-tube, aluminum-fin coil; circuited for integral liquid subcooler, with removable drain pan and brass service valves with service ports.
4. Condenser Fan: Direct-drive, aluminum propeller fan; with permanently lubricated, totally enclosed fan motor with thermal-overload protection and ball bearings, **as directed**.
5. Accessories:
  - a. Coastal Filter: Mesh screen to protect condenser coil from salt damage.
  - b. Crankcase heater.
  - c. Cycle Protector: Automatic-reset timer to prevent rapid compressor cycling.
  - d. Electronic programmable thermostat **OR** Low-voltage thermostat and subbase, **as directed**, to control condensing unit and evaporator fan.
  - e. Evaporator Freeze Thermostat: Temperature-actuated switch that stops unit when evaporator reaches freezing temperature.
  - f. Filter-dryer.
  - g. High-Pressure Switch: Automatic-reset switch cycles compressor off on high refrigerant pressure.
  - h. Liquid-line solenoid.
  - i. Low Ambient Controller: Cycles condenser fan to permit operation down to **0 deg F (minus 18 deg C)** with time-delay relay to bypass low-pressure switch, **as directed**.  
**OR**  
Low Ambient Controller: Controls condenser fan speed to permit operation down to **minus 20 deg F (minus 29 deg C)** with time-delay relay to bypass low-pressure switch, **as directed**.
  - j. Low-Pressure Switch: Automatic-reset switch cycles compressor off on low refrigerant pressure.
  - k. PE mounting base to provide a permanent foundation.
  - l. Precharged and insulated suction and liquid tubing.
  - m. Sound Hood: Wraps around sound attenuation cover for compressor.
  - n. Thermostatic expansion valve.
  - o. Time-Delay Relay: Continues operation of evaporator fan after compressor shuts off.
6. Unit Casing: Galvanized steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Mount service valves, fittings, and gage ports on exterior of casing.

### B. Condensing Units, Air Cooled, **6 To 120 Tons (21 TO 422 kW)**

1. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.

2. Compressor: Hermetic or semihermetic compressor designed for service with crankcase sight glass, crankcase heater, and backseating service access valves on suction and discharge ports.
    - a. Capacity Control: Cylinder unloading **OR** Hot-gas bypass, **as directed**.
    - b. Refrigerant Charge: R-407C **OR** R-410A **OR** HFC-134a, **as directed**.
  3. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and backseating liquid-line service access valve. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.
  4. Condenser Fans: Propeller-type vertical discharge; either directly or belt driven. Include the following:
    - a. Permanently lubricated ball-bearing motors.
    - b. Separate motor for each fan.
    - c. Dynamically and statically balanced fan assemblies.
  5. Operating and safety controls include the following:
    - a. Manual-reset, high-pressure cutout switches.
    - b. Automatic-reset, low-pressure cutout switches.
    - c. Low oil pressure cutout switch.
    - d. Compressor-winding thermostat cutout switch.
    - e. Three-leg, compressor-overload protection.
    - f. Control transformer.
    - g. Magnetic contactors for compressor and condenser fan motors.
    - h. Timer to prevent excessive compressor cycling.
  6. Accessories:
    - a. Electronic programmable thermostat **OR** Low-voltage thermostat and subbase, **as directed**, to control condensing unit and evaporator fan.
    - b. Low Ambient Controller: Cycles condenser fan to permit operation down to 0 deg F (minus 18 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.  
**OR**  
Low Ambient Controller: Controls condenser fan speed to permit operation down to minus 20 deg F (minus 29 deg C) with time-delay relay to bypass low-pressure switch, **as directed**.
    - c. Gage Panel: Package with refrigerant circuit suction and discharge gages.
    - d. Hot-gas bypass kit.
    - e. Part-winding-start timing relay, circuit breakers, and contactors.
  7. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:
    - a. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
    - b. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
    - c. Gasketed control panel door.
    - d. Nonfused disconnect switch, factory mounted and wired, for single external electrical power connection.
    - e. Condenser coil hail guard **OR** grille, **as directed**, to protect coil from physical damage.
- C. Condensing Units, Water Cooled
1. Description: Factory assembled and tested, water cooled; consisting of compressors, water-cooled condensers, bases, and unit controls.
  2. Compressor: Hermetic or serviceable hermetic type; with oil pump, operating oil charge, and suction and discharge shutoff valves. Factory mounted on base using spring isolators. Include the following:
    - a. Thermally protected compressor motor.
    - b. Crankcase heater.
    - c. Capacity control using cylinder unloading, suction pressure controlled and discharge pressure operated, designed for unloaded start.
    - d. Refrigerant Charge: R-407C **OR** R-410A **OR** HFC-134a, **as directed**.

3. Condenser: Single-pass, tube-in-tube coaxial type; with seamless, integral-finned, copper tube and steel outer shell with water-regulating valve.

**OR**

Condenser: Multipass, shell-and-tube type; with replaceable, seamless, integral-finned copper tubes; positive-liquid subcooling circuit; pressure relief device; liquid-level test cock; purge connection; liquid-line shutoff valve; and angle valve for connection of water-regulating valve.

- a. Unit Construction: ASME stamped, **as directed**, for refrigerant-side working pressure of **385 psig (2650 kPa)** and water-side working pressure of **250 psig (1720 kPa)**.
4. Accessories include the following:
  - a. Discharge-line muffler.
  - b. Gage panel containing gages for suction, discharge, and oil pressure.
  - c. Electric solenoid cylinder unloaders.
  - d. Pump-down relay package.
  - e. Crankcase cover plates with equalizer connections.
5. Controls: Factory-mounted and -wired panel with the following:
  - a. Timer to prevent short cycling.
  - b. High- and low-refrigerant-pressure safety controls.
  - c. Power- and control-circuit terminal blocks.
  - d. Compressor motor starter.
  - e. Control-circuit on-off switch.
  - f. Control-circuit fuse.

#### D. Motors

1. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.

#### E. Source Quality Control

1. Verification of Performance: Rate condensing units according to ARI 210/240, ARI 340/360, or ARI 365.
  - a. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
2. Test and inspect shell and tube condensers according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
3. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

### 1.3 EXECUTION

#### A. Installation

1. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
2. Install condensing units on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac" and concrete materials and installation requirements are specified in Division 31.
3. Concrete Bases:
  - a. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around full perimeter of the base.
  - b. For equipment supported on structural slab, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

- d. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
  - 4. Install roof-mounting units on equipment supports specified in Division 07.
  - 5. Vibration Isolation: Mount condensing units on rubber pads with a minimum deflection of **1/4 inch (6.35 mm)**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".  
**OR**  
Vibration Isolation: Mount condensing units on restrained spring isolators with a minimum deflection specified by the Owner. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - 6. Maintain manufacturer's recommended clearances for service and maintenance.
  - 7. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.
- B. Connections
- 1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  - 2. Install piping adjacent to machine to allow service and maintenance.
  - 3. Connect precharged refrigerant tubing to unit's quick-connect fittings. Install tubing so it does not interfere with access to unit. Install furnished accessories.
  - 4. Connect refrigerant piping to air-cooled condensing units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Division 23 Section "Refrigerant Piping".
  - 5. Connect refrigerant and condenser-water piping to water-cooled condensing units. Maintain clear tube removal space. Refrigerant piping and specialties are specified in Division 23 Section "Refrigerant Piping" and condenser-water piping and specialties are specified in Division 22 Section(s) "Domestic Water Piping" OR Division 23 Section(s) "Hydronic Piping", **as directed**.
- C. Field Quality Control
- 1. Perform the following field tests and inspections and prepare test reports:
    - a. Perform electrical test and visual and mechanical inspection.
    - b. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
    - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
    - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - e. Verify proper airflow over coils.
  - 2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
  - 3. Remove and replace malfunctioning condensing units and retest as specified above.
- D. Startup Service
- 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
    - a. Inspect for physical damage to unit casing.
    - b. Verify that access doors move freely and are weathertight.
    - c. Clean units and inspect for construction debris.
    - d. Verify that all bolts and screws are tight.
    - e. Adjust vibration isolation and flexible connections.
    - f. Verify that controls are connected and operational.
  - 2. Lubricate bearings on fans.
  - 3. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
  - 4. Adjust fan belts to proper alignment and tension.



5. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
6. Measure and record airflow over coils.
7. Verify proper operation of condenser capacity control device.
8. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
9. After startup and performance test, lubricate bearings and adjust belt tension, **as directed**.

E. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units.

END OF SECTION 23 01 60 71

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## SECTION 23 05 13 00 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for common motor requirements for HVAC equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

#### C. Coordination

1. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
  - a. Motor controllers.
  - b. Torque, speed, and horsepower requirements of the load.
  - c. Ratings and characteristics of supply circuit and required control sequence.
  - d. Ambient and environmental conditions of installation location.

### 1.2 PRODUCTS

#### A. General Motor Requirements

1. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
2. Comply with NEMA MG 1 unless otherwise indicated.
3. Comply with IEEE 841 for severe-duty motors.

#### B. Motor Characteristics

1. Duty: Continuous duty at ambient temperature of 40 deg C and at altitude of 3300 feet (1000 m) above sea level.
2. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

#### C. Polyphase Motors

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Energy efficient, as defined in NEMA MG 1.
3. Service Factor: 1.15.
4. Multispeed Motors: Variable torque.
  - a. For motors with 2:1 speed ratio, consequent pole, single winding.
  - b. For motors with other than 2:1 speed ratio, separate winding for each speed.
5. Multispeed Motors: Separate winding for each speed.
6. Rotor: Random-wound, squirrel cage.
7. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
8. Temperature Rise: Match insulation rating.
9. Insulation: Class F.
10. Code Letter Designation:
  - a. Motors 15 HP and Larger: NEMA starting Code F or Code G.





- b. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- 11. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

D. Polyphase Motors With Additional Requirements

- 1. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- 2. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
  - a. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
  - b. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
  - c. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
  - d. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.
- 3. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.

E. Single-Phase Motors

- 1. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application:
  - a. Permanent-split capacitor.
  - b. Split phase.
  - c. Capacitor start, inductor run.
  - d. Capacitor start, capacitor run.
- 2. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- 3. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- 4. Motors 1/20 HP and Smaller: Shaded-pole type.
- 5. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

1.3 EXECUTION (Not Applicable)

END OF SECTION 23 05 13 00

## SECTION 23 05 16 00 - EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for expansion fittings and loops for HVAC piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Flexible, ball-joint, packed expansion joints.
  - b. Slip-joint packed expansion joints.
  - c. Expansion-compensator packless expansion joints.
  - d. Flexible-hose packless expansion joints.
  - e. Metal-bellows packless expansion joints.
  - f. Rubber packless expansion joints.
  - g. Grooved-joint expansion joints.
  - h. Pipe loops and swing connections.
  - i. Alignment guides and anchors.

#### C. Performance Requirements

1. Compatibility: Products shall be suitable for piping service fluids, materials, working pressures, and temperatures.
2. Capability: Products to absorb 200 percent of maximum axial movement between anchors.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Delegated-Design Submittal: For each anchor and alignment guide indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
  - b. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
  - c. Alignment Guide Details: Detail field assembly and attachment to building structure.
  - d. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
3. Welding certificates.
4. Product Certificates: For each type of expansion joint, from manufacturer.
5. Maintenance Data: For expansion joints to include in maintenance manuals.

#### E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
  - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
  - b. ASME Boiler and Pressure Vessel Code: Section IX.

### 1.2 PRODUCTS

#### A. Packed Expansion Joints

1. Flexible, Ball-Joint, Packed Expansion Joints:

- a. Standards: ASME Boiler and Pressure Vessel Code: Section II, "Materials"; and ASME B31.9, "Building Services Piping," for materials and design of pressure-containing parts and bolting.
- b. Material: Carbon-steel assembly with asbestos-free composition packing.
- c. Design: For 360-degree rotation and angular deflection.
- d. Minimum Pressure Rating: 250 psig at 400 deg F (1725 kPa at 204 deg C).
- e. Angular Deflection for NPS 6 (DN 150) and Smaller: 30 degree minimum.
- f. Angular Deflection for NPS 8 (DN 200) and Larger: 15 degree minimum.
- g. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
- h. End Connections for NPS 2-1/2 (DN 65) and Larger: Flanged.
2. Slip-Joint Packed Expansion Joints:
  - a. Standard: ASTM F 1007.
  - b. Material: Carbon steel with asbestos-free PTFE packing.
  - c. Design: With internal guide and injection device for repacking under pressure. Include drip connection if used for steam piping.
  - d. Configuration: Single joint **OR** Single joint with base and double joint with base, **as directed**, class(es) unless otherwise indicated.
  - e. End Connections: Flanged or weld ends to match piping system.
- B. Packless Expansion Joints
  1. Metal, Expansion-Compensator Packless Expansion Joints:
    - a. Minimum Pressure Rating: 150 psig (1035 kPa) **OR** 175 psig (1200 kPa), **as directed**, unless otherwise indicated.
    - b. Configuration for Copper Tubing: Two-ply, phosphor-bronze bellows with copper pipe ends.
      - 1) End Connections for Copper Tubing NPS 2 (DN 50) and Smaller: Solder joint or threaded.
      - 2) End Connections for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Threaded.
    - c. Configuration for Steel Piping: Two-ply, stainless-steel bellows; steel-pipe end connections; and carbon-steel shroud.
      - 1) End Connections for Steel Pipe NPS 2 (DN 50) and Smaller: Threaded.
      - 2) End Connections for Steel Pipe NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Flanged **OR** Weld, **as directed**.
  2. Rubber, Expansion-Compensator Packless Expansion Joints:
    - a. Material: Twin reinforced-rubber spheres with external restraining cables.
    - b. Minimum Pressure Rating: 150 psig at 170 deg F (1035 kPa at 77 deg C) unless otherwise indicated.
    - c. End Connections for NPS 2 (DN 50) and Smaller: Threaded.
  3. Flexible-Hose Packless Expansion Joints:
    - a. Description: Manufactured assembly with inlet and outlet elbow fittings and two flexible-metal-hose legs joined by long-radius, 180-degree return bend or center section of flexible hose.
    - b. Flexible Hose: Corrugated-metal inner hoses and braided outer sheaths.
    - c. Expansion Joints for Copper Tubing NPS 2 (DN 50) and Smaller: Copper-alloy fittings with solder-joint end connections.
      - 1) Bronze hoses and single-braid bronze sheaths with 450 psig at 70 deg F (3100 kPa at 21 deg C) and 340 psig at 450 deg F (2340 kPa at 232 deg C) ratings.
      - 2) Bronze hoses and double-braid bronze sheaths with 700 psig at 70 deg F (4830 kPa at 21 deg C) and 500 psig at 450 deg F (3450 kPa at 232 deg C) ratings.
    - d. Expansion Joints for Copper Tubing NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Copper-alloy fittings with threaded end connections.
      - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with 300 psig at 70 deg F (2070 kPa at 21 deg C) and 225 psig at 450 deg F (1550 kPa at 232 deg C) ratings.

- 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with **420 psig at 70 deg F** (2890 kPa at 21 deg C) and **315 psig at 450 deg F** (2170 kPa at 232 deg C) ratings.
- e. Expansion Joints for Steel Piping **NPS 2 (DN 50)** and Smaller: Carbon-steel fittings with threaded end connections.
  - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with **450 psig at 70 deg F** (3100 kPa at 21 deg C) and **325 psig at 600 deg F** (2250 kPa at 315 deg C) ratings.
  - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with **700 psig at 70 deg F** (4830 kPa at 21 deg C) and **515 psig at 600 deg F** (3550 kPa at 315 deg C) ratings.
- f. Expansion Joints for Steel Piping **NPS 2-1/2 to NPS 6 (DN 65 to DN 150)**: Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.
  - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with **200 psig at 70 deg F** (1380 kPa at 21 deg C) and **145 psig at 600 deg F** (1000 kPa at 315 deg C) ratings.
  - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with **275 psig at 70 deg F** (1900 kPa at 21 deg C) and **200 psig at 600 deg F** (1380 kPa at 315 deg C) ratings.
- g. Expansion Joints for Steel Piping **NPS 8 to NPS 12 (DN 200 to DN 300)**: Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.
  - 1) Stainless-steel hoses and single-braid, stainless-steel sheaths with **125 psig at 70 deg F** (860 kPa at 21 deg C) and **90 psig at 600 deg F** (625 kPa at 315 deg C) ratings.
  - 2) Stainless-steel hoses and double-braid, stainless-steel sheaths with **165 psig at 70 deg F** (1130 kPa at 21 deg C) and **120 psig at 600 deg F** (830 kPa at 315 deg C) ratings.
- h. Expansion Joints for Steel Piping **NPS 14 (DN 350)** and Larger: Carbon-steel fittings with flanged **OR** weld, **as directed**, end connections.
  - 1) Stainless-steel hoses and double-braid, stainless-steel sheaths with **165 psig at 70 deg F** (1130 kPa at 21 deg C) and **120 psig at 600 deg F** (830 kPa at 315 deg C) ratings.
4. Metal-Bellows Packless Expansion Joints:
  - a. Standards: ASTM F 1120 and EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
  - b. Type: Circular, corrugated bellows with external tie rods.
  - c. Minimum Pressure Rating: **150 psig (1035 kPa) OR 175 psig (1200 kPa)**, **as directed**, unless otherwise indicated.
  - d. Configuration: Single joint **OR** Single joint with base and double joint with base, **as directed**, class(es) unless otherwise indicated.
  - e. Expansion Joints for Copper Tubing: Single **OR** Multi, **as directed**,-ply phosphor-bronze bellows, copper pipe ends, and brass shrouds.
    - 1) End Connections for Copper Tubing **NPS 2 (DN 50)** and Smaller: Solder joint or threaded.
    - 2) End Connections for Copper Tubing **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Solder joint or threaded.
    - 3) End Connections for Copper Tubing **NPS 5 (DN 125)** and Larger: Flanged.
  - f. Expansion Joints for Steel Piping: Single **OR** Multi, **as directed**,-ply stainless-steel bellows, steel pipe ends, and carbon-steel shroud.
    - 1) End Connections for Steel Pipe **NPS 2 (DN 50)** and Smaller: Threaded.
    - 2) End Connections for Steel Pipe **NPS 2-1/2 (DN 65)** and Larger: Flanged **OR** Weld, **as directed**.
5. Rubber Packless Expansion Joints:
  - a. Standards: ASTM F 1123 and FSA's "Technical Handbook: Non-Metallic Expansion Joints and Flexible Pipe Connectors."
  - b. Material: Fabric-reinforced rubber complying with FSA-NMEJ-703.

- c. Arch Type: Single **OR** Multiple, **as directed**, arches with external control rods, **as directed**.
- d. Spherical Type: Single **OR** Multiple, **as directed**, spheres with external control rods, **as directed**.
- e. Minimum Pressure Rating for **NPS 1-1/2 to NPS 4 (DN 40 to DN 100)**: **150 psig (1035 kPa) at 220 deg F (104 deg C)**.
- f. Minimum Pressure Rating for **NPS 5 and NPS 6 (DN 125 and DN 150)**: **140 psig (966 kPa) at 200 deg F (93 deg C)**.
- g. Minimum Pressure Rating for **NPS 8 to NPS 12 (DN 200 to DN 300)**: **140 psig (966 kPa) at 180 deg F (82 deg C)**.
- h. Material for Fluids Containing Acids, Alkalies, or Chemicals: **BR OR CSM OR EPDM, as directed**.
- i. Material for Fluids Containing Gas, Hydrocarbons, or Oil: **Buna-N OR CR, as directed**.
- j. Material for Water: **BR OR Buna-N OR CR OR CSM OR EPDM OR NR, as directed**.
- k. End Connections: Full-faced, integral steel flanges with steel retaining rings.

C. Grooved-Joint Expansion Joints

- 1. Description: Factory-assembled expansion joint made of several grooved-end pipe nipples, couplings, and grooved joints.
- 2. Standard: AWWA C606, for grooved joints.
- 3. Nipples: Galvanized, **as directed**, ASTM A 53/A 53M, Schedule 40, Type E or S, steel pipe with grooved ends.
- 4. Couplings: Five **OR** Seven **OR** 10 **OR** 12, **as directed**, flexible type for steel-pipe dimensions. Include ferrous housing sections, Buna-N gasket suitable for diluted acid, alkaline fluids, and cold and hot water **OR** EPDM gasket suitable for cold and hot water, **as directed**, and bolts and nuts.

D. Alignment Guides And Anchors

- 1. Alignment Guides:
  - a. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.
- 2. Anchor Materials:
  - a. Steel Shapes and Plates: ASTM A 36/A 36M.
  - b. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
  - c. Washers: ASTM F 844, steel, plain, flat washers.
  - d. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
    - 1) Stud: Threaded, zinc-coated carbon steel.
    - 2) Expansion Plug: Zinc-coated steel.
    - 3) Washer and Nut: Zinc-coated steel.
  - e. Chemical Fasteners: Insert-type-stud, bonding-system anchor for use with hardened portland cement concrete, with tension and shear capacities appropriate for application.
    - 1) Bonding Material: ASTM C 881/C 881M, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed.
    - 2) Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud unless otherwise indicated.
    - 3) Washer and Nut: Zinc-coated steel.

### 1.3 EXECUTION

A. Expansion-Joint Installation

- 1. Install expansion joints of sizes matching sizes of piping in which they are installed.

2. Install packed-type expansion joints with packing suitable for fluid service.
  3. Install metal-bellows expansion joints according to EJMA's "Standards of the Expansion Joint Manufacturers Association, Inc."
  4. Install rubber packless expansion joints according to FSA-NMEJ-702.
  5. Install grooved-joint expansion joints to grooved-end steel piping
- B. Pipe Loop And Swing Connection Installation
1. Install pipe loops cold-sprung in tension or compression as required to partly absorb tension or compression produced during anticipated change in temperature.
  2. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.
  3. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.
  4. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.
- C. Alignment-Guide And Anchor Installation
1. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
  2. Install one **OR** two, **as directed**, guide(s) on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.
  3. Attach guides to pipe and secure guides to building structure.
  4. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
  5. Anchor Attachments:
    - a. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
    - b. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
  6. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
    - a. Anchor Attachment to Steel Structural Members: Attach by welding.
    - b. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
  7. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION 23 05 16 00

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Task	Specification	Specification Description
23 05 17 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 05 17 00	07 63 00 00	Common Work Results for Fire Suppression
23 05 17 00	07 63 00 00a	Common Work Results for Plumbing
23 05 17 00	07 63 00 00b	Common Work Results for HVAC
23 05 19 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 05 19 00	07 63 00 00	Common Work Results for Fire Suppression
23 05 19 00	07 63 00 00a	Common Work Results for Plumbing
23 05 19 00	07 63 00 00b	Common Work Results for HVAC
23 05 19 00	21 05 19 00	Meters and Gages for Plumbing Piping
23 05 19 00	21 05 19 00a	Meters and Gages for HVAC Piping
23 05 23 00	01 22 16 00	No Specification Required
23 05 23 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 05 23 00	13 12 13 00	Water Distribution
23 05 23 00	21 05 23 00a	General-Duty Valves for Plumbing Piping
23 05 23 00	21 05 23 00b	General-Duty Valves for HVAC Piping
23 05 23 00	22 05 76 00a	Storm Drainage Piping Specialties
23 05 23 00	22 11 16 00c	Hydronic Piping
23 05 23 00	22 11 16 00e	Refrigerant Piping
23 05 23 00	22 11 23 23a	Hydronic Pumps
23 05 23 00	22 11 16 00f	General-Service Compressed-Air Piping

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## SECTION 23 05 29 00 - STEAM DISTRIBUTION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for steam distribution. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes underground piping outside the building for distribution of steam and condensate.

#### C. Performance Requirements

1. Provide components and installation capable of producing steam piping systems with the following minimum working-pressure ratings:
  - a. Steam Piping: **15 psig (104 kPa) OR 125 psig (860 kPa), as directed.**
  - b. Condensate Piping: **100 psig (690 kPa).**

#### D. Submittals

1. Product Data:
2. Shop Drawings:
3. Welding certificates.
4. Source quality-control test reports.
5. Field quality-control test reports.

#### E. Quality Assurance

1. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.
2. ASME Compliance: Comply with ASME B31.1, "Power Piping" **OR** ASME B31.9, "Building Services Piping," **as directed**, for materials, products, and installation.
3. ASME Compliance: Safety valves and pressure vessels shall bear appropriate ASME labels.

#### F. Project Conditions

1. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed utility interruptions.
  - b. Do not proceed with utility interruptions without written permission.

### 1.2 PRODUCTS

#### A. Piping Materials

1. Refer to Article 1.3 "Piping Application" for applications of pipes, tubes, fittings, and joining methods.
2. Refer to Division 33 Section "Common Work Results For Utilities" for commonly used joining materials.

#### B. Steel Pipes And Fittings

1. Steel Pipe: ASTM A 53/A 53M, Type E, Grade A, Standard Weight; with plain ends.
2. Nipples: ASTM A 733, Standard Weight, seamless, carbon-steel pipe complying with ASTM A 53/A 53M.

3. Malleable-Iron, Threaded Fittings: ASME B16.3, Classes 150 and 300, with threads according to ASME B1.20.1.
4. Cast-Iron, Threaded Fittings: ASME B16.4, Classes 125 and 250, standard pattern, with threads according to ASME B1.20.1.
5. Steel Welding Fittings: ASME B16.9 and ASTM A 234/A 234M, seamless or welded.

C. Conduit Piping

1. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade A with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
  - a. Mineral-Wool Pipe Insulation: ASTM C 547, Type I, molded.
    - 1) Apparent Thermal Conductivity (k-Value): **0.31 at 200 deg F (0.044 at 93 deg C)** mean temperature.
    - 2) Density: Maximum **10 lb/cu. ft. (160 kg/cu. m)** average.
    - 3) Compressive Strength: **10 psig (69 kPa)** minimum at 5 percent deformation.
    - 4) Bands: ASTM A 666, Type 304, stainless steel, **3/4 inch (19 mm)** wide, **0.020 inch (0.5 mm)** thick.
  - b. Calcium Silicate Pipe Insulation: ASTM C 533, Type I; preformed, incombustible, inorganic, with non-asbestos fibrous reinforcement.
    - 1) Thermal Conductivity (k-Value): **0.60 at 500 deg F (0.087 at 260 deg C)**.
    - 2) Dry Density: **15 lb/cu. ft. (240 kg/cu. m)** maximum.
    - 3) Compressive Strength: **60 psig (414 kPa)** minimum at 5 percent deformation.
    - 4) Bands: ASTM A 666, Type 304, stainless steel, **3/4 inch (19 mm)** wide, **0.020 inch (0.5 mm)** thick.
  - c. Polyisocyanurate Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
    - 1) Thermal Conductivity (k-Value): **0.14 at 75 deg F (0.020 at 24 deg C)**.
    - 2) Service Temperature: **Minus 250 to plus 400 deg F (Minus 156 to plus 204 deg C)**.
    - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
    - 4) Minimum 90 percent closed cell.
    - 5) Dry Density: **2 lb/cu. ft. (32 kg/cu. m)** maximum.
    - 6) Compressive Strength: **35 psig (242 kPa)** minimum at 5 percent deformation.
    - 7) Water-Vapor Transmission: **1.26 perm inches (1.83 ng/Pa x s x m)** according to ASTM E 96.
  - d. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
    - 1) Thermal Conductivity (k-Value): **0.13 at 75 deg F (0.019 at 24 deg C)**.
    - 2) Service Temperature: **Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C)**.
    - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
    - 4) Minimum 90 percent closed cell.
    - 5) Dry Density: **2 lb/cu. ft. (32 kg/cu. m)** maximum.
    - 6) Compressive Strength: **35 psig (242 kPa)** minimum at 5 percent deformation.
    - 7) Water-Vapor Transmission: **1.26 perm inches (1.83 ng/Pa x s x m)** according to ASTM E 96.
4. Minimum Clearance:
  - a. Between Carrier Pipe Insulation and Conduit: **1 inch (25 mm)**.
  - b. Between Insulation of Multiple Carrier Pipes: **3/16 inch (4.75 mm)**.
  - c. Between Bottom of Carrier Pipe Insulation and Conduit: **1 inch (25 mm)**.
  - d. Between Bottom of Bare, Carrier Pipe and Casing: **1-3/8 inches (35 mm)**.
5. Conduit: Spiral wound, steel. Finish conduit with 2 coats of fusion-bonded epoxy, minimum **20 mils (0.50 mm)** thick. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article, **as directed**.
6. Conduit: Spiral wound, bare steel. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article.

7. Carrier Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of **10 feet (3 m)**.
  8. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees shall be factory fabricated and insulated, and shall be compatible with the carrier pipe.
  9. Expansion Offsets and Loops: Size casing to contain piping expansion.
  10. Conduit accessories include the following:
    - a. Water Shed: Terminal end protector for carrier pipes entering building through floor, **3 inches (75 mm)** deep and **2 inches (50 mm)** larger than casing; terminate casing **20 inches (500 mm)** above the floor level.
    - b. Guides and Anchors: Steel plate welded to carrier pipes and to casing, complete with vent and drainage openings inside casing.
    - c. End Seals: Steel plate welded to carrier pipes and to casing, complete with drain and vent openings on vertical centerline.
    - d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of casing, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
    - e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.
  11. Source Quality Control: Factory test the conduit to **15 psig (105 kPa)** for a minimum of 2 minutes with no change in pressure. Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.
- D. Cased Piping
1. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.
  2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade A with beveled **OR** socket, **as directed**, ends for welded joints.
  3. Carrier Pipe Insulation:
    - a. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
      - 1) Thermal Conductivity (k-Value): **0.13 at 75 deg F (0.019 at 24 deg C)**.
      - 2) Service Temperature: **Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C)**.
      - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
      - 4) Minimum 90 percent closed cell.
      - 5) Dry Density: **2 lb/cu. ft. (32 kg/cu. m)** maximum.
      - 6) Compressive Strength: **35 psig (242 kPa)** minimum at 5 percent deformation.
      - 7) Water-Vapor Transmission: **1.26 perm inches (1.83 ng/Pa x s x m)** according to ASTM E 96.
  4. Casing: High-density polyethylene **OR** Filament-wound, fiberglass-reinforced polyester resin **OR** PVC, **as directed**.
  5. Casing accessories include the following:
    - a. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
    - b. Expansion Blanket: Elastomeric foam, formed to fit over piping.
    - c. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.
  6. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.
- E. Loose-Fill Insulation
1. Granular, Loose-Fill Insulation: Inorganic, nontoxic, nonflammable, sodium potassium aluminum silicate with calcium carbonate filler. Include chemical treatment that renders insulation hydrophobic.
    - a. Thermal Conductivity (k-Value): **0.60 at 175 deg F (0.087 at 79 deg C)** and **0.65 at 300 deg F (0.094 at 149 deg C)**.
    - b. Application Temperature Range: **35 to 800 deg F (2 to 426 deg C)**.
    - c. Dry Density: **40 to 42 lb/cu. ft. (640 to 672 kg/cu. m)**.
    - d. Strength: **12,000 lb/sq. ft. (58 600 kg/sq. m)**.

2. Powder, Loose-Fill Insulation: Inert, nontoxic, nonflammable, calcium carbonate particles. Include chemical treatment that renders insulation hydrophobic.
  - a. Thermal Conductivity (k-Value): ASTM C 177, **0.58 at 100 deg F** (**0.084 at 37 deg C**) and **0.68 at 300 deg F** (**0.098 at 149 deg C**).
  - b. Application Temperature Range: **Minus 273 to plus 480 deg F** (**Minus 169 to plus 250 deg C**).
  - c. Dry Density: Approximately **60 lb/cu. ft.** (**960 kg/cu. m**).
  - d. Strength: **12,000 lb/sq. ft.** (**58 600 kg/sq. m**).

### 1.3 EXECUTION

- A. Earthwork: Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
- B. Piping Application
  1. Steam Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.
  2. Steam Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated, **unless directed otherwise to be** coated and insulated, conduit.
    - a. Insulation Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed.**
  3. Condensate Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel welding fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.
  4. Condensate Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
    - a. Insulation Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed.**
  5. Condensate Piping: Cased piping with polyurethane carrier-pipe insulation.
- C. Piping Installation
  1. General Locations and Arrangements: Drawings indicate general location and arrangement of piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved.
  2. Remove any standing water in the bottom of trench.
  3. Bed the pipe on a minimum **6-inch (150-mm)** layer of granular fill material with a minimum **6-inch (150-mm)** clearance between the pipes.
  4. Do not insulate piping or backfill piping trench until field quality-control testing has been completed and results approved.
  5. Install piping at uniform grade of 0.2 percent downward in direction of flow or as indicated.
  6. Install condensate piping at uniform grade of 0.4 percent downward in direction of flow.
  7. Install components with pressure rating equal to or greater than system operating pressure.
  8. Install piping free of sags and bends.
  9. Install fittings for changes in direction and branch connections.
  10. Refer to Division 23 Section "Common Work Results For Hvac" for sleeves and mechanical sleeve seals through exterior building walls.
  11. Secure anchors with concrete thrust blocks. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
  12. Connect to steam and condensate piping where it passes through the building wall. Steam and condensate piping inside the building is specified in Division 23 Section "Steam And Condensate Heating Piping".

- D. Loose-Fill Insulation Installation
1. Do not disturb the bottom of trench, or compact and stabilize it to ensure proper support.
  2. Remove any standing water in the bottom of trench.
  3. Form insulation trench by excavation or by installing drywall side forms to establish the required height and width of the insulation.
  4. Support piping with proper pitch, separation, and clearance to backfill or side forms using temporary supporting devices that can be removed after back filling with insulation.
  5. Place insulation and backfill after field quality-control testing has been completed and results approved.
  6. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. Refer to Division 03 Section "Cast-in-place Concrete" for concrete and reinforcement.
  7. Wrap piping at expansion loops and offsets with mineral-wool insulation of thickness appropriate for calculated expansion amount.
  8. Pour loose-fill insulation to required dimension agitating insulation to eliminate voids around piping.
  9. Remove temporary hangers and supports.
  10. Cover loose-fill insulation with polyethylene sheet a minimum of 4 mils (0.10 mm) thick, and empty loose-fill insulation bags on top.
  11. Manually backfill 6 inches (150 mm) of clean backfill. If mechanical compaction is required manually backfill to 12 inches (300 mm) before using mechanical-compaction equipment.
- E. Joint Construction
1. Refer to Division 33 Section "Common Work Results For Utilities" for basic piping joint construction.
  2. Keyed-Coupling Joints: Cut- or roll-groove pipes. Assemble joints with keyed couplings, gaskets, lubricant, and bolts.
  3. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation, exterior jacket sleeve, and apply shrink-wrap seals as required by manufacturer's written installation instructions.
- F. Identification: Install continuous plastic underground warning tapes during back filling of trenches for underground steam and condensate distribution piping. Locate 6 to 8 inches (150 to 200 mm) below finished grade, directly over piping. Refer to Division 31 Section "Earth Moving" for warning-tape materials and devices and their installation.
- G. Field Quality Control
1. Prepare steam and condensate piping for testing according to ASME B31.1 and ASME B31.9 and as follows:
    - a. Leave joints, including welds, uninsulated and exposed for examination during test.
    - b. Isolate equipment. Do not subject equipment to test pressure.
    - c. Install relief valve set at pressure no more than one-third higher than test pressure.
    - d. Fill system with temperature water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
    - e. Use vents installed at high points to release trapped air while filling system. Use drip legs installed at low points for complete removal of liquid.
  2. Test steam and condensate piping as follows:
    - a. Subject steam and condensate piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
    - b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
  3. Test conduit as follows:
    - a. Seal vents and drains and subject conduit to 15 psig (105 kPa) for 4 hours with no loss of pressure. Repair leaks and retest as required.
  4. Prepare a written report of testing.



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END OF SECTION 23 05 29 00

NOT FOR BID



## SECTION 23 05 29 00a - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for hangers and supports for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Metal pipe hangers and supports.
  - b. Trapeze pipe hangers.
  - c. Fiberglass pipe hangers.
  - d. Metal framing systems.
  - e. Fiberglass strut systems.
  - f. Thermal-hanger shield inserts.
  - g. Fastener systems.
  - h. Pipe stands.
  - i. Equipment supports.

#### C. Definitions

1. MSS: Manufacturers Standardization Society of The Valve and Fittings Industry Inc.

#### D. Performance Requirements

1. Delegated Design: Design trapeze pipe hangers and equipment supports, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
  - a. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
  - b. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
  - c. Design seismic-restraint hangers and supports for piping and equipment and obtain approval from authorities having jurisdiction.

#### E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
  - a. Trapeze pipe hangers.
  - b. Metal framing systems.
  - c. Fiberglass strut systems.
  - d. Pipe stands.
  - e. Equipment supports.
3. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Detail fabrication and assembly of trapeze hangers.
  - b. Design Calculations: Calculate requirements for designing trapeze hangers.

## 4. Welding certificates.

## F. Quality Assurance

1. Structural Steel Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.

## 1.2 PRODUCTS

## A. Metal Pipe Hangers And Supports

1. Carbon-Steel Pipe Hangers and Supports:
  - a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
  - b. Galvanized Metallic Coatings: Pregalvanized or hot dipped.
  - c. Nonmetallic Coatings: Plastic coating, jacket, or liner.
  - d. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
  - e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
2. Stainless-Steel Pipe Hangers and Supports:
  - a. Description: MSS SP-58, Types 1 through 58, factory-fabricated components.
  - b. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion to support bearing surface of piping.
  - c. Hanger Rods: Continuous-thread rod, nuts, and washer made of stainless steel.
3. Copper Pipe Hangers:
  - a. Description: MSS SP-58, Types 1 through 58, copper-coated-steel, factory-fabricated components.
  - b. Hanger Rods: Continuous-thread rod, nuts, and washer made of copper-coated steel **OR** stainless steel, **as directed**.

## B. Trapeze Pipe Hangers

1. Description: MSS SP-69, Type 59, shop- or field-fabricated pipe-support assembly made from structural carbon-steel shapes with MSS SP-58 carbon-steel hanger rods, nuts, saddles, and U-bolts.

## C. Fiberglass Pipe Hangers

1. Clevis-Type, Fiberglass Pipe Hangers:
  - a. Description: Similar to MSS SP-58, Type 1, steel pipe hanger except hanger is made of fiberglass or fiberglass-reinforced resin.
  - b. Hanger Rods: Continuous-thread rod, washer, and nuts made of fiberglass, polyurethane or stainless steel.
2. Strap-Type, Fiberglass Pipe Hangers:
  - a. Description: Similar to MSS SP-58, Type 9 or Type 10, steel pipe hanger except hanger is made of fiberglass-reinforced resin.
  - b. Hanger Rod and Fittings: Continuous-thread rod, washer, and nuts made of stainless steel.

## D. Metal Framing Systems

1. MFMA Manufacturer Metal Framing Systems:
  - a. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
  - b. Standard: MFMA-4.
  - c. Channels: Continuous slotted steel channel with inturned lips.

- d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
- e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
- f. Metallic Coating: Electroplated zinc **OR** Hot-dipped galvanized **OR** Mill galvanized **OR** In-line, hot galvanized **OR** Mechanically-deposited zinc, **as directed**.  
**OR**  
Paint Coating: Vinyl **OR** Vinyl alkyd **OR** Epoxy **OR** Polyester **OR** Acrylic **OR** Amine **OR** Alkyd, **as directed**.  
**OR**  
Plastic Coating: PVC **OR** Polyurethane **OR** Epoxy **OR** Polyester, **as directed**.  
**OR**  
Combination Coating: as directed by the Owner.
- 2. Non-MFMA Manufacturer Metal Framing Systems:
  - a. Description: Shop- or field-fabricated pipe-support assembly made of steel channels, accessories, fittings, and other components for supporting multiple parallel pipes.
  - b. Standard: Comply with MFMA-4.
  - c. Channels: Continuous slotted steel channel with intumed lips.
  - d. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
  - e. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel **OR** stainless steel, **as directed**.
  - f. Coating: Zinc **OR** Paint **OR** PVC, **as directed**.
- E. Fiberglass Strut Systems
  - 1. Description: Shop- or field-fabricated pipe-support assembly similar to MFMA-4 for supporting multiple parallel pipes.
    - a. Channels: Continuous slotted fiberglass or other plastic channel with intumed lips.
    - b. Channel Nuts: Fiberglass nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
    - c. Hanger Rods: Continuous-thread rod, nuts, and washer made of fiberglass **OR** stainless steel, **as directed**.
- F. Thermal-Hanger Shield Inserts
  - 1. Insulation-Insert Material for Cold Piping: ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength and vapor barrier.
  - 2. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate with 100-psig (688-kPa), ASTM C 552, Type II cellular glass with 100-psig (688-kPa) or ASTM C 591, Type VI, Grade 1 polyisocyanurate with 125-psig (862-kPa) minimum compressive strength.
  - 3. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
  - 4. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
  - 5. Insert Length: Extend 2 inches (50 mm) beyond sheet metal shield for piping operating below ambient air temperature.
- G. Fastener Systems
  - 1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
  - 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated **OR** stainless-, **as directed**, steel anchors, for use in hardened portland cement concrete; with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- H. Pipe Stands

1. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
  2. Compact Pipe Stand: One-piece plastic unit with integral-rod roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
  3. Low-Type, Single-Pipe Stand: One-piece plastic **OR** stainless-steel, **as directed**, base unit with plastic roller, for roof installation without membrane penetration.
  4. High-Type, Single-Pipe Stand:
    - a. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
    - b. Base: Plastic **OR** Stainless steel, **as directed**.
    - c. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
    - d. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.
  5. High-Type, Multiple-Pipe Stand:
    - a. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
    - b. Bases: One or more; plastic.
    - c. Vertical Members: Two or more protective-coated-steel channels.
    - d. Horizontal Member: Protective-coated-steel channel.
    - e. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
  6. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.
- I. Equipment Supports
1. Description: Welded, shop- or field-fabricated equipment support made from structural carbon-steel shapes.
- J. Miscellaneous Materials
1. Structural Steel: ASTM A 36/A 36M, carbon-steel plates, shapes, and bars; black and galvanized.
  2. Grout: ASTM C 1107, factory-mixed and -packaged, dry, hydraulic-cement, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
    - a. Properties: Nonstaining, noncorrosive, and nongaseous.
    - b. Design Mix: **5000-psi (34.5-MPa)**, 28-day compressive strength.

### 1.3 EXECUTION

#### A. Hanger And Support Installation

1. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
2. Metal Trapeze Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping, and support together on field-fabricated trapeze pipe hangers.
  - a. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers.
  - b. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
3. Fiberglass Pipe-Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.

4. Metal Framing System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled metal framing systems.
5. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping, and support together on field-assembled fiberglass struts.
6. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
7. Fastener System Installation:
  - a. Install powder-actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches (100 mm) thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder-actuated tool manufacturer's operating manual.
  - b. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
8. Pipe Stand Installation:
  - a. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
  - b. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. See Division 07 Section "Roof Accessories" for curbs.
9. Install hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
10. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
11. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
12. Install lateral bracing with pipe hangers and supports to prevent swaying.
13. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
14. Load Distribution: Install hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
15. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by ASME B31.9 for building services piping.
16. Insulated Piping:
  - a. Attach clamps and spacers to piping.
    - 1) Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
    - 2) Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
    - 3) Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
  - b. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
    - 1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
  - c. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
    - 1) Option: Thermal-hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
  - d. Shield Dimensions for Pipe: Not less than the following:
    - 1) NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches (305 mm) long and 0.048 inch (1.22 mm) thick.
    - 2) NPS 4 (DN 100): 12 inches (305 mm) long and 0.06 inch (1.52 mm) thick.
    - 3) NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches (457 mm) long and 0.06 inch (1.52 mm) thick.



- 4) **NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches (610 mm) long and 0.075 inch (1.91 mm) thick.**
  - 5) **NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches (610 mm) long and 0.105 inch (2.67 mm) thick.**
  - e. Pipes **NPS 8 (DN 200)** and Larger: Include wood or reinforced calcium-silicate-insulation inserts of length at least as long as protective shield.
  - f. Thermal-Hanger Shields: Install with insulation same thickness as piping insulation.
- B. Equipment Supports
1. Fabricate structural-steel stands to suspend equipment from structure overhead or to support equipment above floor.
  2. Grouting: Place grout under supports for equipment and make bearing surface smooth.
  3. Provide lateral bracing, to prevent swaying, for equipment supports.
- C. Metal Fabrications
1. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
  2. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
  3. Field Welding: Comply with AWS D1.1/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
    - a. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
    - b. Obtain fusion without undercut or overlap.
    - c. Remove welding flux immediately.
    - d. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.
- D. Adjusting
1. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
  2. Trim excess length of continuous-thread hanger and support rods to **1-1/2 inches (40 mm)**.
- E. Painting
1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
    - a. Apply paint by brush or spray to provide a minimum dry film thickness of **2.0 mils (0.05 mm)**.
  - OR**
  - Touchup: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 07 OR Division 09 Section(s) "High-performance Coatings", **as directed**.
  2. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.
- F. Hanger And Support Schedule
1. Specific hanger and support requirements are in Sections specifying piping systems and equipment.
  2. Comply with MSS SP-69 for pipe-hanger selections and applications that are not specified in piping system Sections.
  3. Use hangers and supports with galvanized metallic coatings for piping and equipment that will not have field-applied finish.



4. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
5. Use carbon-steel pipe hangers and supports, metal trapeze pipe hangers and metal framing systems and attachments for general service applications.
6. Use stainless-steel pipe hangers and fiberglass pipe hangers and fiberglass strut systems and stainless-steel or corrosion-resistant attachments for hostile environment applications.
7. Use copper-plated pipe hangers and copper or stainless-steel attachments for copper piping and tubing.
8. Use padded hangers for piping that is subject to scratching.
9. Use thermal-hanger shield inserts for insulated piping and tubing.
10. Horizontal-Piping Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - a. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of noninsulated or insulated, stationary pipes **NPS 1/2 to NPS 30 (DN 15 to DN 750)**.
  - b. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of up to **1050 deg F (566 deg C)**, pipes **NPS 4 to NPS 24 (DN 100 to DN 600)**, requiring up to **4 inches (100 mm)** of insulation.
  - c. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes **NPS 3/4 to NPS 36 (DN 20 to DN 900)**, requiring clamp flexibility and up to **4 inches (100 mm)** of insulation.
  - d. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes **NPS 1/2 to NPS 24 (DN 15 to DN 600)** if little or no insulation is required.
  - e. Pipe Hangers (MSS Type 5): For suspension of pipes **NPS 1/2 to NPS 4 (DN 15 to DN 100)**, to allow off-center closure for hanger installation before pipe erection.
  - f. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated, stationary pipes **NPS 3/4 to NPS 8 (DN 20 to DN 200)**.
  - g. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated, stationary pipes **NPS 1/2 to NPS 8 (DN 15 to DN 200)**.
  - h. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated, stationary pipes **NPS 1/2 to NPS 8 (DN 15 to DN 200)**.
  - i. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated, stationary pipes **NPS 1/2 to NPS 8 (DN 15 to DN 200)**.
  - j. Split Pipe Ring with or without Turnbuckle Hangers (MSS Type 11): For suspension of noninsulated, stationary pipes **NPS 3/8 to NPS 8 (DN 10 to DN 200)**.
  - k. Extension Hinged or Two-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated, stationary pipes **NPS 3/8 to NPS 3 (DN 10 to DN 80)**.
  - l. U-Bolts (MSS Type 24): For support of heavy pipes **NPS 1/2 to NPS 30 (DN 15 to DN 750)**.
  - m. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
  - n. Pipe Saddle Supports (MSS Type 36): For support of pipes **NPS 4 to NPS 36 (DN 100 to DN 900)**, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate.
  - o. Pipe Stanchion Saddles (MSS Type 37): For support of pipes **NPS 4 to NPS 36 (DN 100 to DN 900)**, with steel-pipe base stanchion support and cast-iron floor flange or carbon-steel plate, and with U-bolt to retain pipe.
  - p. Adjustable Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes **NPS 2-1/2 to NPS 36 (DN 65 to DN 900)** if vertical adjustment is required, with steel-pipe base stanchion support and cast-iron floor flange.
  - q. Single-Pipe Rolls (MSS Type 41): For suspension of pipes **NPS 1 to NPS 30 (DN 25 to DN 750)**, from two rods if longitudinal movement caused by expansion and contraction might occur.
  - r. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes **NPS 2-1/2 to NPS 24 (DN 65 to DN 600)**, from single rod if horizontal movement caused by expansion and contraction might occur.

- s. Complete Pipe Rolls (MSS Type 44): For support of pipes **NPS 2 to NPS 42 (DN 50 to DN 1050)** if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
- t. Pipe Roll and Plate Units (MSS Type 45): For support of pipes **NPS 2 to NPS 24 (DN 50 to DN 600)** if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
- u. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes **NPS 2 to NPS 30 (DN 50 to DN 750)** if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- 11. Vertical-Piping Clamps: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - a. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers **NPS 3/4 to NPS 24 (DN 24 to DN 600)**.
  - b. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers **NPS 3/4 to NPS 24 (DN 20 to DN 600)** if longer ends are required for riser clamps.
- 12. Hanger-Rod Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - a. Steel Turnbuckles (MSS Type 13): For adjustment up to **6 inches (150 mm)** for heavy loads.
  - b. Steel Clevises (MSS Type 14): For **120 to 450 deg F (49 to 232 deg C)** piping installations.
  - c. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
  - d. Malleable-Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
  - e. Steel Weldless Eye Nuts (MSS Type 17): For **120 to 450 deg F (49 to 232 deg C)** piping installations.
- 13. Building Attachments: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - a. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
  - b. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joint construction, to attach to top flange of structural shape.
  - c. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
  - d. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
  - e. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
  - f. C-Clamps (MSS Type 23): For structural shapes.
  - g. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
  - h. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
  - i. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
  - j. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
  - k. Malleable-Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
  - l. Welded-Steel Brackets: For support of pipes from below or for suspending from above by using clip and rod. Use one of the following for indicated loads:
    - 1) Light (MSS Type 31): **750 lb (340 kg)**.
    - 2) Medium (MSS Type 32): **1500 lb (680 kg)**.
    - 3) Heavy (MSS Type 33): **3000 lb (1360 kg)**.
  - m. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
  - n. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
  - o. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.



14. Saddles and Shields: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - a. Steel-Pipe-Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
  - b. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
  - c. Thermal-Hanger Shield Inserts: For supporting insulated pipe.
15. Spring Hangers and Supports: Unless otherwise indicated and except as specified in piping system Sections, install the following types:
  - a. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
  - b. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches (32 mm).
  - c. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41, roll hanger with springs.
  - d. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
  - e. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from hanger.
  - f. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from base support.
  - g. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to allow expansion and contraction of piping system from trapeze support.
  - h. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability. These supports include the following types:
    - 1) Horizontal (MSS Type 54): Mounted horizontally.
    - 2) Vertical (MSS Type 55): Mounted vertically.
    - 3) Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
16. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
17. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.
18. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

END OF SECTION 23 05 29 00a

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Task	Specification	Specification Description
23 05 29 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 05 29 00	07 63 00 00	Common Work Results for Fire Suppression
23 05 29 00	07 63 00 00a	Common Work Results for Plumbing
23 05 29 00	07 63 00 00b	Common Work Results for HVAC
23 05 29 00	22 05 29 00	Hangers and Supports for Plumbing Piping and Equipment

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## SECTION 23 05 48 13 - VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of vibration and seismic controls for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Isolation pads.
  - b. Isolation mounts.
  - c. Restrained elastomeric isolation mounts.
  - d. Freestanding and Restrained spring isolators.
  - e. Housed spring mounts.
  - f. Elastomeric hangers.
  - g. Spring hangers.
  - h. Spring hangers with vertical-limit stops.
  - i. Pipe riser resilient supports.
  - j. Resilient pipe guides.
  - k. Freestanding and Restrained air-mounting system.
  - l. Restrained vibration isolation roof-curb rails.
  - m. Seismic snubbers.
  - n. Restraining braces and cables.
  - o. Steel and Inertia, vibration isolation equipment bases.

#### C. Definitions

1. IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

#### D. Performance Requirements

1. Wind-Restraint Loading:
  - a. Basic Wind Speed: As required to meet Project requirements.
  - b. Building Classification Category: **I OR II OR III OR IV, as directed.**
  - c. Minimum **10 lb/sq. ft. (48.8 kg/sq. m)** multiplied by the maximum area of the HVAC component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
2. Seismic-Restraint Loading:
  - a. Site Class as Defined in the IBC: **A OR B OR C OR D OR E OR F, as directed.**
  - b. Assigned Seismic Use Group or Building Category as Defined in the IBC: **I OR II OR III, as directed.**
    - 1) Component Importance Factor: **1.0 OR 1.5, as directed.**
    - 2) Component Response Modification Factor: **1.5 OR 2.5 OR 3.5 OR 5.0, as directed.**
    - 3) Component Amplification Factor: **1.0 OR 2.5, as directed.**
  - c. Design Spectral Response Acceleration at Short Periods (0.2 Second): Percentage as directed.
  - d. Design Spectral Response Acceleration at 1-Second Period: Percentage as directed.

#### E. Submittals

1. Product Data: For each product indicated.



2. Delegated-Design Submittal: For vibration isolation and seismic-restraint calculations and details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Qualification Data: For professional engineer.
5. Field quality-control test reports.

F. Quality Assurance

1. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

## 1.2 PRODUCTS

A. Vibration Isolators

1. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
  - a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
2. Mounts: Double-deflection type, with molded, oil-resistant rubber, hermetically sealed compressed fiberglass, or neoprene isolator elements with factory-drilled, encapsulated top plate for bolting to equipment and with baseplate for bolting to structure. Color-code or otherwise identify to indicate capacity range.
  - a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
  - b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
3. Restrained Mounts: All-directional mountings with seismic restraint.
  - a. Materials: Cast-ductile-iron or welded steel housing containing two separate and opposing, oil-resistant rubber or neoprene elements that prevent central threaded element and attachment hardware from contacting the housing during normal operation.
  - b. Neoprene: Shock-absorbing materials compounded according to the standard for bridge-bearing neoprene as defined by AASHTO.
4. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
  - a. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - b. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - c. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - d. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  - e. Baseplates: Factory drilled for bolting to structure and bonded to **1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).**

- f. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- 5. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
  - a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to ~~1/4-inch-~~ (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
  - b. Restraint: Seismic or limit stop as required for equipment and authorities having jurisdiction.
  - c. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - d. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - e. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - f. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- 6. Housed Spring Mounts: Housed spring isolator with integral seismic snubbers.
  - a. Housing: Ductile-iron or steel housing to provide all-directional seismic restraint.
  - b. Base: Factory drilled for bolting to structure.
  - c. Snubbers: Vertically adjustable to allow a maximum of ~~1/4-inch~~ (6-mm) travel up or down before contacting a resilient collar.
- 7. Elastomeric Hangers: Single or double-deflection type, fitted with molded, oil-resistant elastomeric isolator elements bonded to steel housings with threaded connections for hanger rods. Color-code or otherwise identify to indicate capacity range.
- 8. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
  - a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
  - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
  - g. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.
- 9. Spring Hangers with Vertical-Limit Stop: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression and with a vertical-limit stop.
  - a. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
  - b. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
  - g. Adjustable Vertical Stop: Steel washer with neoprene washer "up-stop" on lower threaded rod.
  - h. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

10. Pipe Riser Resilient Support: All-directional, acoustical pipe anchor consisting of 2 steel tubes separated by a minimum of **1/2-inch- (13-mm-)** thick neoprene. Include steel and neoprene vertical-limit stops arranged to prevent vertical travel in both directions. Design support for a maximum load on the isolation material of **500 psig (3.45 MPa)** and for equal resistance in all directions.
11. Resilient Pipe Guides: Telescopic arrangement of 2 steel tubes or post and sleeve arrangement separated by a minimum of **1/2-inch- (13-mm-)** thick neoprene. Where clearances are not readily visible, a factory-set guide height with a shear pin to allow vertical motion due to pipe expansion and contraction shall be fitted. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of motion to meet location requirements.

#### B. Air-Mounting Systems

1. Air Mounts: Freestanding, single or multiple, compressed-air bellows.
  - a. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows.
  - b. Maximum Natural Frequency: 3 Hz.
  - c. Operating Pressure Range: **25 to 100 psig (172 to 690 kPa)**.
  - d. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
  - e. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus **1/8 inch (3 mm)**.
2. Restrained Air Mounts: Housed compressed-air bellows.
  - a. Assembly: Upper and lower steel sections connected by a replaceable, flexible, nylon-reinforced neoprene bellows and spring, with angle-iron frame having vertical-limit stops and channel-section top with leveling adjustment and attachment screws.
  - b. Maximum Natural Frequency: 3 Hz.
  - c. Operating Pressure Range: **25 to 100 psig (172 to 690 kPa)**.
  - d. Burst Pressure: At least three times manufacturer's published maximum operating pressure.
  - e. Leveling Valves: Minimum of 3 required to maintain leveling within plus or minus **1/8 inch (3 mm)**.

#### C. Restrained Vibration Isolation Roof-Curb Rails

1. General Requirements for Restrained Vibration Isolation Roof-Curb Rails: Factory-assembled, fully enclosed, insulated, air- and watertight curb rail designed to resiliently support equipment and to withstand seismic and wind, **as directed**, forces.
2. Lower Support Assembly: Formed sheet-metal section containing adjustable and removable steel springs that support upper frame. Upper frame shall provide continuous support for equipment and shall be captive to resiliently resist seismic and wind, **as directed**, forces. Lower support assembly shall have a means for attaching to building structure and a wood nailer for attaching roof materials, and shall be insulated with a minimum of **2 inches (50 mm)** of rigid, glass-fiber insulation on inside of assembly.
3. Spring Isolators: Adjustable, restrained spring isolators shall be mounted on **1/4-inch- (6-mm-)** thick, elastomeric vibration isolation pads and shall have access ports, for level adjustment, with removable waterproof covers at all isolator locations. Isolators shall be located so they are accessible for adjustment at any time during the life of the installation without interfering with the integrity of the roof.
  - a. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or wind, **as directed**, restraint.
    - 1) Housing: Steel with resilient vertical-limit stops and adjustable equipment mounting and leveling bolt.
    - 2) Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
    - 3) Minimum Additional Travel: 50 percent of the required deflection at rated load.



- 4) Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - 5) Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  - b. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
    - 1) Resilient Material: Oil- and water-resistant standard neoprene **OR** natural rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
  4. Snubber Bushings: All-directional, elastomeric snubber bushings at least **1/4 inch (6 mm)** thick.
  5. Water Seal: Galvanized sheet metal with EPDM seals at corners, attached to upper support frame, extending down past wood nailer of lower support assembly, and counterflashed over roof materials.
- D. Vibration Isolation Equipment Bases
1. Steel Base: Factory-fabricated, welded, structural-steel bases and rails.
    - a. Design Requirements: Lowest possible mounting height with not less than **1-inch (25-mm)** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
      - 1) Include supports for suction and discharge elbows for pumps.
    - b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
    - c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
  2. Inertia Base: Factory-fabricated, welded, structural-steel bases and rails ready for placement of cast-in-place concrete.
    - a. Design Requirements: Lowest possible mounting height with not less than **1-inch (25-mm)** clearance above the floor. Include equipment anchor bolts and auxiliary motor slide bases or rails.
      - 1) Include supports for suction and discharge elbows for pumps.
    - b. Structural Steel: Steel shapes, plates, and bars complying with ASTM A 36/A 36M. Bases shall have shape to accommodate supported equipment.
    - c. Support Brackets: Factory-welded steel brackets on frame for outrigger isolation mountings and to provide for anchor bolts and equipment support.
    - d. Fabrication: Fabricate steel templates to hold equipment anchor-bolt sleeves and anchors in place during placement of concrete. Obtain anchor-bolt templates from supported equipment manufacturer.
- E. Seismic-Restraint Devices
1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
    - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
  2. Snubbers: Factory fabricated using welded structural-steel shapes and plates, anchor bolts, and replaceable resilient isolation washers and bushings.
    - a. Anchor bolts for attaching to concrete shall be seismic-rated, drill-in, and stud-wedge or female-wedge type.
    - b. Resilient Isolation Washers and Bushings: Oil- and water-resistant neoprene.
    - c. Maximum **1/4-inch (6-mm)** air gap, and minimum **1/4-inch- (6-mm-)** thick resilient cushion.
  3. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

4. Restraint Cables: ASTM A 603 galvanized-steel **OR** ASTM A 492 stainless-steel, **as directed**, cables with end connections made of steel assemblies with thimbles, brackets, swivel, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
5. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
6. Bushings for Floor-Mounted Equipment Anchor Bolts: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchor bolts and studs.
7. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices used.
8. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
9. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
10. Adhesive Anchor Bolts: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

F. Factory Finishes

1. Finish
  - a. Manufacturer's standard prime-coat finish ready for field painting.  
**OR**  
Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
    - 1) Powder coating on springs and housings.
    - 2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
    - 3) Baked enamel or powder coat for metal components on isolators for interior use.
    - 4) Color-code or otherwise mark vibration isolation and seismic-control and wind-control, **as directed**, devices to indicate capacity range.

### 1.3 EXECUTION

A. Applications

1. Multiple Pipe Supports: Secure pipes to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

B. Vibration-Control And Seismic-Restraint Device Installation

1. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
2. Equipment Restraints:

- a. Install seismic snubbers on HVAC equipment mounted on vibration isolators. Locate snubbers as close as possible to vibration isolators and bolt to equipment base and supporting structure.
  - b. Install resilient bolt isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds **0.125 inch (3.2 mm)**.
  - c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
3. Piping Restraints:
  - a. Comply with requirements in MSS SP-127.
  - b. Space lateral supports a maximum of **40 feet (12 m)** o.c., and longitudinal supports a maximum of **80 feet (24 m)** o.c.
  - c. Brace a change of direction longer than **12 feet (3.7 m)**.
4. Install cables so they do not bend across edges of adjacent equipment or building structure.
5. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
6. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
7. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
8. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
9. Drilled-in Anchors:
  - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
  - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
  - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
  - d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
  - e. Set anchors to manufacturer's recommended torque, using a torque wrench.
  - f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.
- C. Accommodation Of Differential Seismic Motion
  1. Install flexible connections in piping where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where the connections terminate with connection to equipment that is anchored to a different structural element from the one supporting the connections as they approach equipment. Comply with requirements in Division 23 Section "Hydronic Piping" for piping flexible connections.
- D. Field Quality Control
  1. Perform tests and inspections.
  2. Tests and Inspections:
    - a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.

- b. Schedule test with the Owner before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
  - c. Obtain approval before transmitting test loads to structure. Provide temporary load-spreading members.
  - d. Test at least four of each type and size of installed anchors and fasteners selected.
  - e. Test to 90 percent of rated proof load of device.
  - f. Measure isolator restraint clearance.
  - g. Measure isolator deflection.
  - h. Verify snubber minimum clearances.
  - i. Air-Mounting System Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - j. Air-Mounting System Operational Test: Test the compressed-air leveling system.
  - k. Test and adjust air-mounting system controls and safeties.
  - l. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
3. Remove and replace malfunctioning units and retest as specified above.
  4. Prepare test and inspection reports.

E. Adjusting

1. Adjust isolators after piping system is at operating weight.
2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
3. Adjust air-spring leveling mechanism.
4. Adjust active height of spring isolators.
5. Adjust restraints to permit free movement of equipment within normal mode of operation.

F. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain air-mounting systems.

END OF SECTION 23 05 48 13



Task	Specification	Specification Description
23 05 48 13	01 22 16 00	No Specification Required
23 05 48 13	21 05 23 00	Piped Utilities Basic Materials And Methods
23 05 48 13	21 05 48 13	Vibration And Seismic Controls For Fire-Suppression Piping And Equipment
23 05 48 13	22 05 48 13	Vibration And Seismic Controls For Plumbing Piping And Equipment
23 05 48 13	22 11 16 00c	Hydronic Piping
23 05 48 13	22 11 16 00d	Steam And Condensate Piping
23 05 48 13	22 11 16 00e	Refrigerant Piping
23 05 48 13	22 11 16 00f	General-Service Compressed-Air Piping

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## SECTION 23 05 53 00 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for identification for HVAC piping and equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Equipment labels.
  - b. Warning signs and labels.
  - c. Pipe labels.
  - d. Duct labels.
  - e. Stencils.
  - f. Valve tags.
  - g. Warning tags.

#### C. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Equipment Labels

1. Metal Labels for Equipment:
  - a. Material and Thickness: Brass, **0.032-inch (0.8-mm)** OR Stainless steel, **0.025-inch (0.64-mm)** OR Aluminum, **0.032-inch (0.8-mm)** OR anodized aluminum, **0.032-inch (0.8-mm)**, **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.
  - b. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch (64 by 19 mm)**.
  - c. Minimum Letter Size: **1/4 inch (6.4 mm)** for name of units if viewing distance is less than **24 inches (600 mm)**, **1/2 inch (13 mm)** for viewing distances up to **72 inches (1830 mm)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  - d. Fasteners: Stainless-steel rivets OR self-tapping screws, **as directed**.
  - e. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
2. Plastic Labels for Equipment:
  - a. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/16 inch (1.6 mm)** OR **1/8 inch (3.2 mm)**, **as directed**, thick, and having predrilled holes for attachment hardware.
  - b. Letter Color: Black OR Blue OR Red OR White OR Yellow, **as directed**.
  - c. Background Color: Black OR Blue OR Red OR White OR Yellow, **as directed**.
  - d. Maximum Temperature: Able to withstand temperatures up to **160 deg F (71 deg C)**.
  - e. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch (64 by 19 mm)**.
  - f. Minimum Letter Size: **1/4 inch (6.4 mm)** for name of units if viewing distance is less than **24 inches (600 mm)**, **1/2 inch (13 mm)** for viewing distances up to **72 inches (1830 mm)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  - g. Fasteners: Stainless-steel rivets OR self-tapping screws, **as directed**.

- h. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
  3. Label Content: Include equipment's Drawing designation or unique equipment number, Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified.
  4. Equipment Label Schedule: For each item of equipment to be labeled, on **8-1/2-by-11-inch (A4)** bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.
- B. Warning Signs And Labels**
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/16 inch (1.6 mm) OR 1/8 inch (3.2 mm), as directed**, thick, and having predrilled holes for attachment hardware.
  2. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  3. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  4. Maximum Temperature: Able to withstand temperatures up to **160 deg F (71 deg C)**.
  5. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch (64 by 19 mm)**.
  6. Minimum Letter Size: **1/4 inch (6.4 mm)** for name of units if viewing distance is less than **24 inches (600 mm)**, **1/2 inch (13 mm)** for viewing distances up to **72 inches (1830 mm)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  7. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
  8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
  9. Label Content: Include caution and warning information, plus emergency notification instructions.
- C. Pipe Labels**
1. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
  2. Pretensioned Pipe Labels: Precoiled, semirigid plastic formed to partially cover **OR** cover full, **as directed**, circumference of pipe and to attach to pipe without fasteners or adhesive.
  3. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent-adhesive backing.
  4. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
    - a. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
    - b. Lettering Size: At least **1-1/2 inches (38 mm)** high.
- D. Duct Labels**
1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, **1/16 inch (1.6 mm) OR 1/8 inch (3.2 mm), as directed**, thick, and having predrilled holes for attachment hardware.
  2. Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  3. Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  4. Maximum Temperature: Able to withstand temperatures up to **160 deg F (71 deg C)**.
  5. Minimum Label Size: Length and width vary for required label content, but not less than **2-1/2 by 3/4 inch (64 by 19 mm)**.
  6. Minimum Letter Size: **1/4 inch (6.4 mm)** for name of units if viewing distance is less than **24 inches (600 mm)**, **1/2 inch (13 mm)** for viewing distances up to **72 inches (1830 mm)**, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
  7. Fasteners: Stainless-steel rivets **OR** self-tapping screws, **as directed**.
  8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.



9. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
  - a. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
  - b. Lettering Size: At least 1-1/2 inches (38 mm) high.

E. Stencils

1. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches (32 mm) for ducts; and minimum letter height of 3/4 inch (19 mm) for access panel and door labels, equipment labels, and similar operational instructions.
  - a. Stencil Material: Aluminum **OR** Brass **OR** Fiberboard, **as directed**.
  - b. Stencil Paint: Exterior, gloss, alkyd enamel **OR** acrylic enamel, **as directed**, black unless otherwise indicated. Paint may be in pressurized spray-can form.
  - c. Identification Paint: Exterior, alkyd enamel **OR** acrylic enamel, **as directed**, in colors according to ASME A13.1 unless otherwise indicated.

F. Valve Tags

1. Valve Tags: Stamped or engraved with 1/4-inch (6.4-mm) letters for piping system abbreviation and 1/2-inch (13-mm) numbers.
  - a. Tag Material: Brass, 0.032-inch (0.8-mm) **OR** Stainless steel, 0.025-inch (0.64-mm) **OR** Aluminum, 0.032-inch (0.8-mm) **OR** anodized aluminum, 0.032-inch (0.8-mm), **as directed**, minimum thickness, and having predrilled or stamped holes for attachment hardware.
  - b. Fasteners: Brass wire-link chain **OR** beaded chain **OR** S-hook, **as directed**.
2. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
  - a. Valve-tag schedule shall be included in operation and maintenance data.

G. Warning Tags

1. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
  - a. Size: 3 by 5-1/4 inches (75 by 133 mm) minimum **OR** Approximately 4 by 7 inches (100 by 178 mm), **as directed**.
  - b. Fasteners: Brass grommet and wire **OR** Reinforced grommet and wire or string, **as directed**.
  - c. Nomenclature: Large-size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
  - d. Color: Yellow background with black lettering.

### 1.3 EXECUTION

A. Preparation

1. Clean piping and equipment surfaces of substances that could impair bond of identification devices, including dirt, oil, grease, release agents, and incompatible primers, paints, and encapsulants.

B. Equipment Label Installation

1. Install or permanently fasten labels on each major item of mechanical equipment.
2. Locate equipment labels where accessible and visible.

C. Pipe Label Installation

1. Piping Color-Coding: Painting of piping is specified in Division 09 Section(s) "Interior Painting" **OR** "High-performance Coatings", **as directed**.

2. Stenciled Pipe Label Option: Stenciled labels may be provided instead of manufactured pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands or rectangles **OR** complying with ASME A13.1, **as directed**, on each piping system.
  - a. Identification Paint: Use for contrasting background.
  - b. Stencil Paint: Use for pipe marking.
3. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
  - a. Near each valve and control device.
  - b. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
  - c. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
  - d. At access doors, manholes, and similar access points that permit view of concealed piping.
  - e. Near major equipment items and other points of origination and termination.
  - f. Spaced at maximum intervals of **50 feet (15 m)** along each run. Reduce intervals to **25 feet (7.6 m)** in areas of congested piping and equipment.
  - g. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
4. Pipe Label Color Schedule:
  - a. Chilled-Water Piping:
    - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
    - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  - b. Condenser-Water Piping:
    - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
    - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  - c. Heating Water Piping:
    - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
    - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  - d. Refrigerant Piping:
    - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
    - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  - e. Low-Pressure Steam Piping:
    - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
    - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  - f. High-Pressure Steam Piping:
    - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
    - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
  - g. Steam Condensate Piping:
    - 1) Background Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.
    - 2) Letter Color: Black **OR** Blue **OR** Red **OR** White **OR** Yellow, **as directed**.

#### D. Duct Label Installation

1. Install plastic-laminated **OR** self-adhesive, **as directed**, duct labels with permanent adhesive on air ducts in the following color codes:
  - a. Blue: For cold-air supply ducts.
  - b. Yellow: For hot-air supply ducts.
  - c. Green: For exhaust-, outside-, relief-, return-, and mixed-air ducts.
  - d. ASME A13.1 Colors and Designs: For hazardous material exhaust.
2. Stenciled Duct Label Option: Stenciled labels, showing service and flow direction, may be provided instead of plastic-laminated duct labels, at Installer's option, if lettering larger than **1 inch (25 mm)** high is needed for proper identification because of distance from normal location of required identification.
3. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of **50 feet (15 m)** in each space where ducts are exposed or concealed by removable ceiling system.

E. Valve-Tag Installation

1. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience and lawn-watering hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
2. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
  - a. Valve-Tag Size and Shape:
    - 1) Chilled Water: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, round **OR** square, **as directed**.
    - 2) Condenser Water: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, round **OR** square, **as directed**.
    - 3) Refrigerant: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, round **OR** square, **as directed**.
    - 4) Hot Water: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, round **OR** square, **as directed**.
    - 5) Gas: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, round **OR** square, **as directed**.
    - 6) Low-Pressure Steam: **1-1/2 inches (38 mm) 2 inches (50 mm), as directed**, round **OR** square, **as directed**.
    - 7) High-Pressure Steam: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, round **OR** square, **as directed**.
    - 8) Steam Condensate: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, round **OR** square, **as directed**.
  - b. Valve-Tag Color:
    - 1) Chilled Water: Natural **OR** Green, **as directed**.
    - 2) Condenser Water: Natural **OR** Green, **as directed**.
    - 3) Refrigerant: Natural **OR** Green, **as directed**.
    - 4) Hot Water: Natural **OR** Green, **as directed**.
    - 5) Gas: Natural **OR** Yellow, **as directed**.
    - 6) Low-Pressure Steam: Natural **OR** Yellow, **as directed**.
    - 7) High-Pressure Steam: Natural **OR** Green, **as directed**.
    - 8) Steam Condensate: Natural **OR** Green, **as directed**.
  - c. Letter Color:
    - 1) Chilled Water: Black **OR** White, **as directed**.
    - 2) Condenser Water: Black **OR** White, **as directed**.
    - 3) Refrigerant: Black **OR** White, **as directed**.
    - 4) Hot Water: Black **OR** White, **as directed**.
    - 5) Gas: Black **OR** White, **as directed**.
    - 6) Low-Pressure Steam: Black **OR** White, **as directed**.
    - 7) High-Pressure Steam: Black **OR** White, **as directed**.
    - 8) Steam Condensate: Black **OR** White, **as directed**.

F. Warning-Tag Installation

1. Write required message on, and attach warning tags to, equipment and other items where required.

END OF SECTION 23 05 53 00

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Task	Specification	Specification Description
23 05 53 00	22 05 53 00	Identification for Plumbing Piping and Equipment
23 05 53 00	23 01 10 91	Sequence Of Operation
23 05 93 00	01 71 23 16	Cutting and Patching
23 05 93 00	02 41 13 13	Selective Demolition
23 05 93 00	23 01 10 91	Sequence Of Operation
23 05 93 00	23 01 10 91a	Testing, Adjusting, And Balancing

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## SECTION 23 07 13 00 - HVAC INSULATION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC insulation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Insulation Materials:
    - 1) Calcium silicate.
    - 2) Cellular glass.
    - 3) Flexible elastomeric.
    - 4) Mineral fiber.
    - 5) Phenolic.
    - 6) Polyisocyanurate.
    - 7) Polyolefin.
    - 8) Polystyrene.
  - b. Fire-rated insulation systems.
  - c. Insulating cements.
  - d. Adhesives.
  - e. Mastics.
  - f. Lagging adhesives.
  - g. Sealants.
  - h. Factory-applied jackets.
  - i. Field-applied fabric-reinforcing mesh.
  - j. Field-applied cloths.
  - k. Field-applied jackets.
  - l. Tapes.
  - m. Securements.
  - n. Corner angles.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
  - a. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:
  - a. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
  - b. Detail attachment and covering of heat tracing inside insulation.
  - c. Detail insulation application at pipe expansion joints for each type of insulation.
  - d. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
  - e. Detail removable insulation at piping specialties, equipment connections, and access panels.
  - f. Detail application of field-applied jackets.
  - g. Detail application at linkages of control devices.
  - h. Detail field application for each equipment type.
4. Field quality-control reports.

## D. Quality Assurance

1. Fire-Test-Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing and inspecting agency.
  - a. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
  - b. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

## E. Delivery, Storage, And Handling

1. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

## 1.2 PRODUCTS

## A. Insulation Materials

1. Comply with requirements in Part 1.3 schedule articles for where insulating materials shall be applied.
2. Products shall not contain asbestos, lead, mercury, or mercury compounds.
3. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
4. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
5. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
6. Calcium Silicate:
  - a. Preformed Pipe Sections: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
  - b. Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a non-asbestos fibrous reinforcement. Comply with ASTM C 533, Type I.
  - c. Prefabricated Fitting Covers: Comply with ASTM C 450 and ASTM C 585 for dimensions used in preforming insulation to cover valves, elbows, tees, and flanges.
7. Cellular Glass: Inorganic, incombustible, foamed or cellulated glass with annealed, rigid, hermetically sealed cells. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - a. Block Insulation: ASTM C 552, Type I.
  - b. Special-Shaped Insulation: ASTM C 552, Type III.
  - c. Board Insulation: ASTM C 552, Type IV.
  - d. Preformed Pipe Insulation without Jacket: Comply with ASTM C 552, Type II, Class 1.
  - e. Preformed Pipe Insulation with Factory-Applied ASJ **OR** ASJ-SSL, **as directed**: Comply with ASTM C 552, Type II, Class 2.
  - f. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
8. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
9. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I **OR** II with factory-applied vinyl jacket **OR** III with factory-applied FSK jacket **OR** III with factory-applied FSP jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
10. High-Temperature, Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type V, without factory-applied jacket.



11. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. For equipment applications, provide insulation without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied FSK jacket, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
12. High-Temperature, Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type III, without factory-applied jacket.
13. Mineral-Fiber, Preformed Pipe Insulation:
  - a. Type I, **850 deg F (454 deg C)** Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
  - b. Type II, **1200 deg F (649 deg C)** Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type II, Grade A, without factory-applied jacket **OR** with factory-applied ASJ **OR** with factory-applied ASJ-SSL, **as directed**. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
14. Mineral-Fiber, Pipe Insulation Wicking System: Preformed pipe insulation complying with ASTM C 547, Type I, Grade A, with absorbent cloth factory applied to the entire inside surface of preformed pipe insulation and extended through the longitudinal joint to outside surface of insulation under insulation jacket. Factory apply a white, polymer, vapor-retarder jacket with self-sealing adhesive tape seam and evaporation holes running continuously along the longitudinal seam, exposing the absorbent cloth.
15. Mineral-Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semirigid board material with factory-applied ASJ **OR** FSK jacket, **as directed**, complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is **2.5 lb/cu. ft. (40 kg/cu. m)** or more. Thermal conductivity (k-value) at **100 deg F (55 deg C)** is **0.29 Btu x in./h x sq. ft. x deg F (0.042 W/m x K)** or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
16. Phenolic:
  - a. Preformed pipe insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type III, Grade 1.
  - b. Block insulation of rigid, expanded, closed-cell structure. Comply with ASTM C 1126, Type II, Grade 1.
  - c. Factory fabricate shapes according to ASTM C 450 and ASTM C 585.
  - d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
    - 1) Preformed Pipe Insulation: None **OR** ASJ, **as directed**.
    - 2) Board for Duct and Plenum Applications: None **OR** ASJ, **as directed**.
    - 3) Board for Equipment Applications: None **OR** ASJ, **as directed**.
17. Polyisocyanurate: Unfaced, preformed, rigid cellular polyisocyanurate material intended for use as thermal insulation.
  - a. Comply with ASTM C 591, Type I or Type IV, except thermal conductivity (k-value) shall not exceed **0.19 Btu x in./h x sq. ft. x deg F (0.027 W/m x K)** at **75 deg F (24 deg C)** after 180 days of aging.
  - b. Flame-spread index shall be 25 or less and smoke-developed index shall be 50 or less for thickness up to **1-1/2 inches (38 mm)** as tested by ASTM E 84.
  - c. Fabricate shapes according to ASTM C 450 and ASTM C 585.
  - d. Factory-Applied Jacket: Requirements are specified in "Factory-Applied Jackets" Article.
    - 1) Pipe Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
    - 2) Equipment Applications: None **OR** ASJ **OR** ASJ-SSL **OR** PVDC **OR** PVDC-SSL, **as directed**.
18. Polyolefin: Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials.
19. Polystyrene: Rigid, extruded cellular polystyrene intended for use as thermal insulation. Comply with ASTM C 578, Type IV or Type XIII, except thermal conductivity (k-value) shall not exceed

**0.26 Btu x in./h x sq. ft. x deg F (0.038 W/m x K)** after 180 days of aging. Fabricate shapes according to ASTM C 450 and ASTM C 585.

**B. Fire-Rated Insulation Systems**

1. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to **1700 deg F (927 deg C)**. Comply with ASTM C 656, Type II, Grade 6. tested and certified to provide a 1-hour **OR** 2-hour, **as directed**, fire rating by a NRTL acceptable to authority having jurisdiction.
2. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1-hour **OR** 2-hour, **as directed**, fire rating by a NRTL acceptable to authority having jurisdiction.

**C. Insulating Cements**

1. Mineral-Fiber Insulating Cement: Comply with ASTM C 195.
2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C 196.
3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

**D. Adhesives**

1. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
2. Calcium Silicate Adhesive: Fibrous, sodium-silicate-based adhesive with a service temperature range of **50 to 800 deg F (10 to 427 deg C)**.
  - a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of **minus 75 to plus 300 deg F (minus 59 to plus 149 deg C)**.
  - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
  - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
  - a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Polystyrene Adhesive: Solvent- or water-based, synthetic resin adhesive with a service temperature range of **minus 20 to plus 140 deg F (29 to plus 60 deg C)**.
7. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
  - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
8. PVC Jacket Adhesive: Compatible with PVC jacket.
  - a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

**E. Mastics**

1. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
  - a. For indoor applications, use mastics that have an approved VOC content or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
  - a. Water-Vapor Permeance: ASTM E 96, Procedure B, **0.013 perm (0.009 metric perm)** at **43-mil (1.09-mm)** dry film thickness.

- b. Service Temperature Range: **Minus 20 to plus 180 deg F (Minus 29 to plus 82 deg C).**
      - c. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
      - d. Color: White.
    - 3. Vapor-Barrier Mastic: Solvent based; suitable for indoor use on below ambient services.
      - a. Water-Vapor Permeance: ASTM F 1249, **0.05 perm (0.03 metric perm)** at **35-mil (0.9-mm)** dry film thickness.
      - b. Service Temperature Range: **0 to 180 deg F (Minus 18 to plus 82 deg C).**
      - c. Solids Content: ASTM D 1644, 44 percent by volume and 62 percent by weight.
      - d. Color: White.
    - 4. Vapor-Barrier Mastic: Solvent based; suitable for outdoor use on below ambient services.
      - a. Water-Vapor Permeance: ASTM F 1249, **0.05 perm (0.033 metric perm)** at **30-mil (0.8-mm)** dry film thickness.
      - b. Service Temperature Range: **Minus 50 to plus 220 deg F (Minus 46 to plus 104 deg C).**
      - c. Solids Content: ASTM D 1644, 33 percent by volume and 46 percent by weight.
      - d. Color: White.
    - 5. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
      - a. Water-Vapor Permeance: ASTM F 1249, **3 perms (2 metric perms)** at **0.0625-inch (1.6-mm)** dry film thickness.
      - b. Service Temperature Range: **Minus 20 to plus 200 deg F (Minus 29 to plus 93 deg C).**
      - c. Solids Content: 63 percent by volume and 73 percent by weight.
      - d. Color: White.
- F. Lagging Adhesives
  - 1. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
    - a. For indoor applications, use lagging adhesives that have an approved VOC content when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - b. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
    - c. Service Temperature Range: **Minus 50 to plus 180 deg F (Minus 46 to plus 82 deg C).**
    - d. Color: White.
- G. Sealants
  - 1. Joint Sealants:
    - a. Materials shall be compatible with insulation materials, jackets, and substrates.
    - b. Permanently flexible, elastomeric sealant.
    - c. Service Temperature Range: **Minus 100 to plus 300 deg F (Minus 73 to plus 149 deg C).**
    - d. Color: White or gray.
    - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 2. FSK and Metal Jacket Flashing Sealants:
    - a. Materials shall be compatible with insulation materials, jackets, and substrates.
    - b. Fire- and water-resistant, flexible, elastomeric sealant.
    - c. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
    - d. Color: Aluminum.
    - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
    - a. Materials shall be compatible with insulation materials, jackets, and substrates.
    - b. Fire- and water-resistant, flexible, elastomeric sealant.
    - c. Service Temperature Range: **Minus 40 to plus 250 deg F (Minus 40 to plus 121 deg C).**
    - d. Color: White.
    - e. For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

H. Factory-Applied Jackets

1. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
  - a. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
  - b. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
  - c. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.
  - d. FSP Jacket: Aluminum-foil, fiberglass-reinforced scrim with polyethylene backing; complying with ASTM C 1136, Type II.
  - e. PVDC Jacket for Indoor Applications: 4-mil- (0.10-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.02 perms (0.013 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
  - f. PVDC Jacket for Outdoor Applications: 6-mil- (0.15-mm-) thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perms (0.007 metric perms) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
  - g. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.
- I. Vinyl Jacket: White vinyl with a permeance of 1.3 perms (0.86 metric perms) when tested according to ASTM E 96, Procedure A, and complying with NFPA 90A and NFPA 90B.
- J. Field-Applied Fabric-Reinforcing Mesh
  1. Woven Glass-Fiber Fabric for Pipe Insulation: Approximately 2 oz./sq. yd. (68 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm) for covering pipe and pipe fittings.
  2. Woven Glass-Fiber Fabric for Duct and Equipment Insulation: Approximately 6 oz./sq. yd. (203 g/sq. m) with a thread count of 5 strands by 5 strands/sq. inch (2 strands by 2 strands/sq. mm) for covering equipment.
  3. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq. inch (4 strands by 4 strands/sq. mm), in a Leno weave, for duct, equipment, and pipe.
- K. Field-Applied Cloths
  1. Woven Glass-Fiber Fabric: Comply with MIL-C-20079H, Type I, plain weave, and presized a minimum of 8 oz./sq. yd. (271 g/sq. m).
- L. Field-Applied Jackets
  1. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
  2. FSK Jacket: Aluminum-foil-face, fiberglass-reinforced scrim with kraft-paper backing.
  3. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
    - a. Adhesive: As recommended by jacket material manufacturer.
    - b. Color: White **OR** Color-code jackets based on system. Color as selected by the Owner, **as directed**.
    - c. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
      - 1) Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
    - d. Factory-fabricated tank heads and tank side panels.
  4. Metal Jacket:



- a. Aluminum Jacket: Comply with **ASTM B 209** (**ASTM B 209M**), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
  - 1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
  - 2) Finish and thickness are indicated in field-applied jacket schedules.
  - 3) Moisture Barrier for Indoor Applications: **1-mil-** (**0.025-mm-**) thick, heat-bonded polyethylene and kraft paper **OR 3-mil-** (**0.075-mm-**) thick, heat-bonded polyethylene and kraft paper **OR 2.5-mil-** (**0.063-mm-**) thick Polysurlyn, **as directed**.
  - 4) Moisture Barrier for Outdoor Applications: **3-mil-** (**0.075-mm-**) thick, heat-bonded polyethylene and kraft paper **OR 2.5-mil-** (**0.063-mm-**) thick Polysurlyn, **as directed**.
  - 5) Factory-Fabricated Fitting Covers:
    - a) Same material, finish, and thickness as jacket.
    - b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    - c) Tee covers.
    - d) Flange and union covers.
    - e) End caps.
    - f) Beveled collars.
    - g) Valve covers.
    - h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
- b. Stainless-Steel Jacket: ASTM A 167 or ASTM A 240/A 240M.
  - 1) Sheet and roll stock ready for shop or field sizing **OR** Factory cut and rolled to size, **as directed**.
  - 2) Material, finish, and thickness are indicated in field-applied jacket schedules.
  - 3) Moisture Barrier for Indoor Applications: **1-mil-** (**0.025-mm-**) thick, heat-bonded polyethylene and kraft paper **OR 3-mil-** (**0.075-mm-**) thick, heat-bonded polyethylene and kraft paper **OR 2.5-mil-** (**0.063-mm-**) thick Polysurlyn, **as directed**.
  - 4) Moisture Barrier for Outdoor Applications: **3-mil-** (**0.075-mm-**) thick, heat-bonded polyethylene and kraft paper **OR 2.5-mil-** (**0.063-mm-**) thick Polysurlyn, **as directed**.
  - 5) Factory-Fabricated Fitting Covers:
    - a) Same material, finish, and thickness as jacket.
    - b) Preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows.
    - c) Tee covers.
    - d) Flange and union covers.
    - e) End caps.
    - f) Beveled collars.
    - g) Valve covers.
    - h) Field fabricate fitting covers only if factory-fabricated fitting covers are not available.
5. Underground Direct-Buried Jacket: **125-mil-** (**3.2-mm-**) thick vapor barrier and waterproofing membrane consisting of a rubberized bituminous resin reinforced with a woven-glass fiber or polyester scrim and laminated aluminum foil.
6. Self-Adhesive Outdoor Jacket: **60-mil-** (**1.5-mm-**) thick, laminated vapor barrier and waterproofing membrane for installation over insulation located aboveground outdoors; consisting of a rubberized bituminous resin on a crosslaminated polyethylene film covered with white **OR** stucco-embossed, **as directed**, aluminum-foil facing.
7. PVDC Jacket for Indoor Applications: **4-mil-** (**0.10-mm-**) thick, white PVDC biaxially oriented barrier film with a permeance at **0.02 perms** (**0.013 metric perms**) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 20 when tested according to ASTM E 84.
8. PVDC Jacket for Outdoor Applications: **6-mil-** (**0.15-mm-**) thick, white PVDC biaxially oriented barrier film with a permeance at **0.01 perms** (**0.007 metric perms**) when tested according to ASTM E 96 and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.
9. PVDC-SSL Jacket: PVDC jacket with a self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip.

## M. Tapes

1. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
  - a. Width: 3 inches (75 mm).
  - b. Thickness: 11.5 mils (0.29 mm).
  - c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
  - d. Elongation: 2 percent.
  - e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
  - f. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
2. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
  - a. Width: 3 inches (75 mm).
  - b. Thickness: 6.5 mils (0.16 mm).
  - c. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
  - d. Elongation: 2 percent.
  - e. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
  - f. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
3. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
  - a. Width: 2 inches (50 mm).
  - b. Thickness: 6 mils (0.15 mm).
  - c. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
  - d. Elongation: 500 percent.
  - e. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.
4. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
  - a. Width: 2 inches (50 mm).
  - b. Thickness: 3.7 mils (0.093 mm).
  - c. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
  - d. Elongation: 5 percent.
  - e. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.
5. PVDC Tape for Indoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
  - a. Width: 3 inches (75 mm).
  - b. Film Thickness: 4 mils (0.10 mm).
  - c. Adhesive Thickness: 1.5 mils (0.04 mm).
  - d. Elongation at Break: 145 percent.
  - e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.
6. PVDC Tape for Outdoor Applications: White vapor-retarder PVDC tape with acrylic adhesive.
  - a. Width: 3 inches (75 mm).
  - b. Film Thickness: 6 mils (0.15 mm).
  - c. Adhesive Thickness: 1.5 mils (0.04 mm).
  - d. Elongation at Break: 145 percent.
  - e. Tensile Strength: 55 lbf/inch (10.1 N/mm) in width.

## N. Securements

1. Bands:
  - a. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**; 0.015 inch (0.38 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
  - b. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch (0.51 mm) thick, 1/2 inch (13 mm) **OR** 3/4 inch (19 mm), **as directed**, wide with wing seal **OR** closed seal, **as directed**.
  - c. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
2. Insulation Pins and Hangers:

- a. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, **0.106-inch- (2.6-mm-)** OR **0.135-inch- (3.5-mm-)**, **as directed**, diameter shank, length to suit depth of insulation indicated.
- b. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, **0.106-inch- (2.6-mm-)** OR **0.135-inch- (3.5-mm-)**, **as directed**, diameter shank, length to suit depth of insulation indicated with integral **1-1/2-inch (38-mm)** galvanized carbon-steel washer.
- c. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
  - 1) Baseplate: Perforated, galvanized carbon-steel sheet, **0.030 inch (0.76 mm)** thick by **2 inches (50 mm)** square.
  - 2) Spindle: Copper- or zinc-coated, low carbon steel OR Aluminum OR Stainless steel, **as directed**, fully annealed, **0.106-inch- (2.6-mm-)** diameter shank, length to suit depth of insulation indicated.
  - 3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- d. Nonmetal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate fastened to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
  - 1) Baseplate: Perforated, nylon sheet, **0.030 inch (0.76 mm)** thick by **1-1/2 inches (38 mm)** in diameter.
  - 2) Spindle: Nylon, **0.106-inch- (2.6-mm-)** diameter shank, length to suit depth of insulation indicated, up to **2-1/2 inches (63 mm)**.
  - 3) Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
- e. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
  - 1) Baseplate: Galvanized carbon-steel sheet, **0.030 inch (0.76 mm)** thick by **2 inches (50 mm)** square.
  - 2) Spindle: Copper- or zinc-coated, low carbon steel OR Aluminum OR Stainless steel, **as directed**, fully annealed, **0.106-inch- (2.6-mm-)** diameter shank, length to suit depth of insulation indicated.
  - 3) Adhesive-backed base with a peel-off protective cover.
- f. Insulation-Retaining Washers: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick, galvanized-steel OR aluminum OR stainless-steel, **as directed**, sheet, with beveled edge sized as required to hold insulation securely in place but not less than **1-1/2 inches (38 mm)** in diameter.
  - 1) Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- g. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than **1-1/2 inches (38 mm)** in diameter.
3. Staples: Outward-clinching insulation staples, nominal **3/4-inch- (19-mm-)** wide, stainless steel or Monel.
4. Wire: **0.080-inch (2.0-mm)** nickel-copper alloy OR **0.062-inch (1.6-mm)** soft-annealed, stainless steel OR **0.062-inch (1.6-mm)** soft-annealed, galvanized steel, **as directed**.

O. Corner Angles

1. PVC Corner Angles: **30 mils (0.8 mm)** thick, minimum **1 by 1 inch (25 by 25 mm)**, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

2. Aluminum Corner Angles: **0.040 inch (1.0 mm)** thick, minimum **1 by 1 inch (25 by 25 mm)**, aluminum according to **ASTM B 209 (ASTM B 209M)**, Alloy 3003, 3005, 3105 or 5005; Temper H-14.
3. Stainless-Steel Corner Angles: **0.024 inch (0.61 mm)** thick, minimum **1 by 1 inch (25 by 25 mm)**, stainless steel according to ASTM A 167 or ASTM A 240/A 240M, Type 304 **OR** Type 316, **as directed**.

### 1.3 EXECUTION

#### A. Preparation

1. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.  
**OR**  
Surface Preparation: Clean and prepare surfaces to be insulated. Before insulating, apply a corrosion coating to insulated surfaces as follows:
  - a. Stainless Steel: Coat 300 series stainless steel with an epoxy primer **5 mils (0.127 mm)** thick and an epoxy finish **5 mils (0.127 mm)** thick if operating in a temperature range between **140 and 300 deg F (60 and 149 deg C)**. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
  - b. Carbon Steel: Coat carbon steel operating at a service temperature between **32 and 300 deg F (0 and 149 deg C)** with an epoxy coating. Consult coating manufacturer for appropriate coating materials and application methods for operating temperature range.
2. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
3. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

#### B. General Installation Requirements

1. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and piping including fittings, valves, and specialties.
2. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, and pipe system as specified in insulation system schedules.
3. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
4. Install insulation with longitudinal seams at top and bottom of horizontal runs.
5. Install multiple layers of insulation with longitudinal and end seams staggered.
6. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
7. Keep insulation materials dry during application and finishing.
8. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
9. Install insulation with least number of joints practical.
10. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
  - a. Install insulation continuously through hangers and around anchor attachments.
  - b. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
  - c. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.



- d. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.
  11. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
  12. Install insulation with factory-applied jackets as follows:
    - a. Draw jacket tight and smooth.
    - b. Cover circumferential joints with 3-inch- (75-mm-) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches (100 mm) o.c.
    - c. Overlap jacket longitudinal seams at least 1-1/2 inches (38 mm). Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches (50 mm) OR 4 inches (100 mm), as directed, o.c.
      - 1) For below ambient services, apply vapor-barrier mastic over staples.
    - d. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
    - e. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct and pipe flanges and fittings.
  13. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
  14. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
  15. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
  16. For above ambient services, do not install insulation to the following:
    - a. Vibration-control devices.
    - b. Testing agency labels and stamps.
    - c. Nameplates and data plates.
    - d. Manholes.
    - e. Handholes.
    - f. Cleanouts.
- C. Penetrations
1. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
    - a. Seal penetrations with flashing sealant.
    - b. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
    - c. Extend jacket of outdoor insulation outside roof flashing at least 2 inches (50 mm) below top of roof flashing.
    - d. Seal jacket to roof flashing with flashing sealant.
  2. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
  3. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
    - a. Seal penetrations with flashing sealant.
    - b. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
    - c. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches (50 mm).
    - d. Seal jacket to wall flashing with flashing sealant.

4. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
  5. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions. Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least **2 inches (50 mm)**.
    - a. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.
  6. Insulation Installation at Floor Penetrations:
    - a. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least **2 inches (50 mm)**.
    - b. Pipe: Install insulation continuously through floor penetrations.
    - c. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping".
- D. Equipment, Tank, And Vessel Insulation Installation
1. Mineral Fiber, Pipe and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
    - a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of tank and vessel surfaces.
    - b. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
    - c. Protect exposed corners with secured corner angles.
    - d. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
      - 1) Do not weld anchor pins to ASME-labeled pressure vessels.
      - 2) Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
      - 3) On tanks and vessels, maximum anchor-pin spacing is **3 inches (75 mm)** from insulation end joints, and **16 inches (400 mm)** o.c. in both directions.
      - 4) Do not overcompress insulation during installation.
      - 5) Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
      - 6) Impale insulation over anchor pins and attach speed washers.
      - 7) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
    - e. Secure each layer of insulation with stainless-steel or aluminum bands. Select band material compatible with insulation materials.
    - f. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch prestressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately **6 inches (150 mm)** from each end. Install wire or cable between two circumferential girdles **12 inches (300 mm)** o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch prestressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of **48 inches (1200 mm)** o.c. Use this network for securing insulation with tie wire or bands.
    - g. Stagger joints between insulation layers at least **3 inches (75 mm)**.
    - h. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.

- i. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
    - j. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
  - 2. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
    - a. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
    - b. Seal longitudinal seams and end joints.
  - 3. Insulation Installation on Pumps:
    - a. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on **6-inch (150-mm)** centers, starting at corners. Install **3/8-inch- (10-mm-)** diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
    - b. Fabricate boxes from galvanized steel **OR** aluminum **OR** stainless steel, **as directed**, at least **0.040 inch (1.0 mm) OR 0.050 inch (1.3 mm) OR 0.060 inch (1.6 mm)**, **as directed**, thick.
    - c. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.
- E. General Pipe Insulation Installation
  - 1. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
  - 2. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
    - a. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
    - b. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
    - c. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
    - d. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
    - e. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below ambient services, provide a design that maintains vapor barrier.
    - f. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
    - g. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below ambient services and a breather mastic for above ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
    - h. For services not specified to receive a field-applied jacket except for flexible elastomeric and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and

- unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
- i. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
  3. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
  4. Install removable insulation covers at locations indicated. Installation shall conform to the following:
    - a. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
    - b. When flange and union covers are made from sectional pipe insulation, extend insulation from flange or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
    - c. Construct removable valve insulation covers in same manner as for flanges except divide the two-part section on the vertical center line of valve body.
    - d. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least **2 inches (50 mm)** over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
    - e. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.
- F. Calcium Silicate Insulation Installation
1. Insulation Installation on Boiler Breechings and Ducts:
    - a. Secure single-layer insulation with stainless-steel bands at **12-inch (300-mm)** intervals and tighten bands without deforming insulation material.
    - b. Install 2-layer insulation with joints tightly butted and staggered at least **3 inches (75 mm)**. Secure inner layer with wire spaced at **12-inch (300-mm)** intervals. Secure outer layer with stainless-steel bands at **12-inch (300-mm)** intervals.
    - c. On exposed applications without metal jacket, finish insulation surface with a skim coat of mineral-fiber, hydraulic-setting cement. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth. Overlap edges at least **1 inch (25 mm)**. Apply finish coat of lagging adhesive over glass cloth. Thin finish coat to achieve smooth, uniform finish.
  2. Insulation Installation on Straight Pipes and Tubes:
    - a. Secure single-layer insulation with stainless-steel bands at **12-inch (300-mm)** intervals and tighten bands without deforming insulation materials.
    - b. Install 2-layer insulation with joints tightly butted and staggered at least **3 inches (75 mm)**. Secure inner layer with wire spaced at **12-inch (300-mm)** intervals. Secure outer layer with stainless-steel bands at **12-inch (300-mm)** intervals.
    - c. Apply a skim coat of mineral-fiber, hydraulic-setting cement to insulation surface. When cement is dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least **1 inch (25 mm)**. Apply finish coat of lagging adhesive over glass cloth or tape. Thin finish coat to achieve smooth, uniform finish.
  3. Insulation Installation on Pipe Flanges:
    - a. Install preformed pipe insulation to outer diameter of pipe flange.
    - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

- c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
    - d. Finish flange insulation same as pipe insulation.
  - 4. Insulation Installation on Pipe Fittings and Elbows:
    - a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
    - b. When preformed insulation sections of insulation are not available, install mitered sections of calcium silicate insulation. Secure insulation materials with wire or bands.
    - c. Finish fittings insulation same as pipe insulation.
  - 5. Insulation Installation on Valves and Pipe Specialties:
    - a. Install mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
    - b. Install insulation to flanges as specified for flange insulation application.
    - c. Finish valve and specialty insulation same as pipe insulation.
- G. Cellular-Glass Insulation Installation
  - 1. Insulation Installation on Straight Pipes and Tubes:
    - a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
    - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
    - c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at **6 inches (150 mm)** o.c.
    - d. For insulation with factory-applied jackets on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
  - 2. Insulation Installation on Pipe Flanges:
    - a. Install preformed pipe insulation to outer diameter of pipe flange.
    - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
    - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of same thickness as pipe insulation.
    - d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least **1 inch (25 mm)**, and seal joints with flashing sealant.
  - 3. Insulation Installation on Pipe Fittings and Elbows:
    - a. Install preformed sections of same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
    - b. When preformed sections of insulation are not available, install mitered sections of cellular-glass insulation. Secure insulation materials with wire or bands.
  - 4. Insulation Installation on Valves and Pipe Specialties:
    - a. Install preformed sections of cellular-glass insulation to valve body.
    - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
    - c. Install insulation to flanges as specified for flange insulation application.
- H. Flexible Elastomeric Insulation Installation
  - 1. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 2. Insulation Installation on Pipe Flanges:
    - a. Install pipe insulation to outer diameter of pipe flange.
    - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.



- c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of same thickness as pipe insulation.
  - d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- 3. Insulation Installation on Pipe Fittings and Elbows:
  - a. Install mitered sections of pipe insulation.
  - b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- 4. Insulation Installation on Valves and Pipe Specialties:
  - a. Install preformed valve covers manufactured of same material as pipe insulation when available.
  - b. When preformed valve covers are not available, install cut sections of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  - c. Install insulation to flanges as specified for flange insulation application.
  - d. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

I. Mineral-Fiber Insulation Installation

- 1. Insulation Installation on Straight Pipes and Tubes:
  - a. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
  - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
  - c. For insulation with factory-applied jackets on above ambient surfaces, secure laps with outward clinched staples at **6 inches (150 mm)** o.c.
  - d. For insulation with factory-applied jackets on below ambient surfaces, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
- 2. Insulation Installation on Pipe Flanges:
  - a. Install preformed pipe insulation to outer diameter of pipe flange.
  - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
  - d. Install jacket material with manufacturer's recommended adhesive, overlap seams at least **1 inch (25 mm)**, and seal joints with flashing sealant.
- 3. Insulation Installation on Pipe Fittings and Elbows:
  - a. Install preformed sections of same material as straight segments of pipe insulation when available.
  - b. When preformed insulation elbows and fittings are not available, install mitered sections of pipe insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire or bands.
- 4. Insulation Installation on Valves and Pipe Specialties:
  - a. Install preformed sections of same material as straight segments of pipe insulation when available.
  - b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
  - c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  - d. Install insulation to flanges as specified for flange insulation application.
- 5. Blanket Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

- a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of duct and plenum surfaces.
  - b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - c. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - 1) On duct sides with dimensions **18 inches (450 mm)** and smaller, place pins along longitudinal centerline of duct. Space **3 inches (75 mm)** maximum from insulation end joints, and **16 inches (400 mm)** o.c.
    - 2) On duct sides with dimensions larger than **18 inches (450 mm)**, place pins **16 inches (400 mm)** o.c. each way, and **3 inches (75 mm)** maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
    - 3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
    - 4) Do not overcompress insulation during installation.
    - 5) Impale insulation over pins and attach speed washers.
    - 6) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
  - d. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing **2 inches (50 mm)** from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with **1/2-inch (13-mm)** outward-clinching staples, **1 inch (25 mm)** o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
    - 1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
    - 2) Install vapor stops for ductwork and plenums operating below **50 deg F (10 deg C)** at **18-foot (5.5-m)** intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than **3 inches (75 mm)**.
  - e. Overlap unfaced blankets a minimum of **2 inches (50 mm)** on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of **18 inches (450 mm)** o.c.
  - f. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
  - g. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with **6-inch- (150-mm-)** wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced **6 inches (150 mm)** o.c.
6. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
- a. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 **OR** 50, **as directed**, percent coverage of duct and plenum surfaces.
  - b. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
  - c. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
    - 1) On duct sides with dimensions **18 inches (450 mm)** and smaller, place pins along longitudinal centerline of duct. Space **3 inches (75 mm)** maximum from insulation end joints, and **16 inches (400 mm)** o.c.
    - 2) On duct sides with dimensions larger than **18 inches (450 mm)**, space pins **16 inches (400 mm)** o.c. each way, and **3 inches (75 mm)** maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.

- 3) Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
- 4) Do not overcompress insulation during installation.
- 5) Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
- d. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing **2 inches (50 mm)** from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with **1/2-inch (13-mm)** outward-clinching staples, **1 inch (25 mm)** o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
  - 1) Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
  - 2) Install vapor stops for ductwork and plenums operating below **50 deg F (10 deg C)** at **18-foot (5.5-m)** intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 2 times the insulation thickness but not less than **3 inches (75 mm)**.
- e. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
- f. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with **6-inch- (150-mm-)** wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced **6 inches (150 mm)** o.c.

#### J. Phenolic Insulation Installation

1. General Installation Requirements:
  - a. Secure single-layer insulation with stainless-steel bands at **12-inch (300-mm)** intervals and tighten bands without deforming insulation materials.
  - b. Install 2-layer insulation with joints tightly butted and staggered at least **3 inches (75 mm)**. Secure inner layer with **0.062-inch (1.6-mm)** wire spaced at **12-inch (300-mm)** intervals. Secure outer layer with stainless-steel bands at **12-inch (300-mm)** intervals.
2. Insulation Installation on Straight Pipes and Tubes:
  - a. Secure each layer of insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
  - b. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
  - c. For insulation with factory-applied jackets on above ambient services, secure laps with outward clinched staples at **6 inches (150 mm)** o.c.
  - d. For insulation with factory-applied jackets with vapor retarders on below ambient services, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.
3. Insulation Installation on Pipe Flanges:
  - a. Install preformed pipe insulation to outer diameter of pipe flange.
  - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
  - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of same material and thickness as pipe insulation.
4. Insulation Installation on Pipe Fittings and Elbows:
  - a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
5. Insulation Installation on Valves and Pipe Specialties:



- a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
  - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  - c. Install insulation to flanges as specified for flange insulation application.
- K. Polyisocyanurate Insulation Installation
- 1. Insulation Installation on Straight Pipes and Tubes:
    - a. Secure each layer of insulation to pipe with tape or bands and tighten without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
    - b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
    - c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
  - 2. Insulation Installation on Pipe Flanges:
    - a. Install preformed pipe insulation to outer diameter of pipe flange.
    - b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed 1-1/2-inch (38-mm) thickness.
    - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyisocyanurate block insulation of same thickness as pipe insulation.
  - 3. Insulation Installation on Fittings and Elbows:
    - a. Install preformed sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
  - 4. Insulation Installation on Valves and Pipe Specialties:
    - a. Install preformed sections of polyisocyanurate insulation to valve body.
    - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
    - c. Install insulation to flanges as specified for flange insulation application.
- L. Polyolefin Insulation Installation
- 1. Insulation Installation on Straight Pipes and Tubes:
    - a. Seal split-tube longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 2. Insulation Installation on Pipe Flanges:
    - a. Install pipe insulation to outer diameter of pipe flange.
    - b. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.
    - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polyolefin sheet insulation of same thickness as pipe insulation.
    - d. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 3. Insulation Installation on Pipe Fittings and Elbows:
    - a. Install mitered sections of polyolefin pipe insulation.
    - b. Secure insulation materials and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
  - 4. Insulation Installation on Valves and Pipe Specialties:
    - a. Install cut sections of polyolefin pipe and sheet insulation to valve body.
    - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
    - c. Install insulation to flanges as specified for flange insulation application.

- d. Secure insulation to valves and specialties, and seal seams with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

**M. Polystyrene Insulation Installation**

1. Insulation Installation on Straight Pipes and Tubes:
  - a. Secure each layer of insulation with tape or bands and tighten bands without deforming insulation materials. Orient longitudinal joints between half sections in 3 and 9 o'clock positions on the pipe.
  - b. For insulation with factory-applied jackets with vapor barriers, do not staple longitudinal tabs but secure tabs with additional adhesive or tape as recommended by insulation material manufacturer and seal with vapor-barrier mastic.
  - c. All insulation shall be tightly butted and free of voids and gaps at all joints. Vapor barrier must be continuous. Before installing jacket material, install vapor-barrier system.
2. Insulation Installation on Pipe Flanges:
  - a. Install preformed pipe insulation to outer diameter of pipe flange.
  - b. Make width of insulation section same as overall width of flange and bolts, same thickness of adjacent pipe insulation, not to exceed **1-1/2-inch (38-mm)** thickness.
  - c. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of polystyrene block insulation of same thickness as pipe insulation.
3. Insulation Installation on Pipe Fittings and Elbows:
  - a. Install preformed insulation sections of same material as straight segments of pipe insulation. Secure according to manufacturer's written instructions.
4. Insulation Installation on Valves and Pipe Specialties:
  - a. Install preformed section of polystyrene insulation to valve body.
  - b. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.
  - c. Install insulation to flanges as specified for flange insulation application.

**N. Field-Applied Jacket Installation**

1. Where glass-cloth jackets are indicated, install directly over bare insulation or insulation with factory-applied jackets.
  - a. Draw jacket smooth and tight to surface with **2-inch (50-mm)** overlap at seams and joints.
  - b. Embed glass cloth between two **0.062-inch- (1.6-mm-)** thick coats of lagging adhesive.
  - c. Completely encapsulate insulation with coating, leaving no exposed insulation.
2. Where FSK jackets are indicated, install as follows:
  - a. Draw jacket material smooth and tight.
  - b. Install lap or joint strips with same material as jacket.
  - c. Secure jacket to insulation with manufacturer's recommended adhesive.
  - d. Install jacket with **1-1/2-inch (38-mm)** laps at longitudinal seams and **3-inch- (75-mm-)** wide joint strips at end joints.
  - e. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-barrier mastic.
3. Where PVC jackets are indicated, install with **1-inch (25-mm)** overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
  - a. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
4. Where metal jackets are indicated, install with **2-inch (50-mm)** overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands **12 inches (300 mm)** o.c. and at end joints.
5. Where PVDC jackets are indicated, install as follows:

- a. Apply three separate wraps of filament tape per insulation section to secure pipe insulation to pipe prior to installation of PVDC jacket.
  - b. Wrap factory-presizes jackets around individual pipe insulation sections with one end overlapping the previously installed sheet. Install presized jacket with an approximate overlap at butt joint of **2 inches (50 mm)** over the previous section. Adhere lap seal using adhesive or SSL, and then apply 1-1/4 circumferences of appropriate PVDC tape around overlapped butt joint.
  - c. Continuous jacket can be spiral wrapped around a length of pipe insulation. Apply adhesive or PVDC tape at overlapped spiral edge. When electing to use adhesives, refer to manufacturer's written instructions for application of adhesives along this spiral edge to maintain a permanent bond.
  - d. Jacket can be wrapped in cigarette fashion along length of roll for insulation systems with an outer circumference of **33-1/2 inches (850 mm)** or less. The **33-1/2-inch- (850-mm-)** circumference limit allows for **2-inch- (50-mm-)** overlap seal. Using the length of roll allows for longer sections of jacket to be installed at one time. Use adhesive on the lap seal. Visually inspect lap seal for "fishmouthing," and use PVDC tape along lap seal to secure joint.
  - e. Repair holes or tears in PVDC jacket by placing PVDC tape over the hole or tear and wrapping a minimum of 1-1/4 circumferences to avoid damage to tape edges.
- O. Fire-Rated Insulation System Installation
1. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
  2. Insulate duct access panels and doors to achieve same fire rating as duct.
  3. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Penetration Firestopping".
- P. Finishes
1. Duct, Equipment, and Pipe Insulation with ASJ, Glass-Cloth, or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 07.
    - a. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
      - 1) Finish Coat Material: Interior, flat, latex-emulsion size.
  2. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
  3. Color: Final color as selected by the Owner. Vary first and second coats to allow visual inspection of the completed Work.
  4. Do not field paint aluminum or stainless-steel jackets.
- Q. Field Quality Control
1. Perform tests and inspections.
  2. Tests and Inspections:
    - a. Inspect ductwork, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each duct system defined in the "Duct Insulation Schedule, General" Article.
    - b. Inspect field-insulated equipment, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location(s) for each type of equipment defined in the "Equipment Insulation Schedule" Article. For large equipment, remove only a portion adequate to determine compliance.
    - c. Inspect pipe, fittings, strainers, and valves, randomly selected by the Owner, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations

of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

3. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

**R. Boiler Breeching Insulation Schedule**

1. Round, exposed breeching and connector insulation shall be one of the following:
  - a. Calcium Silicate: **4 inches (100 mm)** thick.
  - b. High-Temperature Mineral-Fiber Blanket: **3 inches (75 mm)** thick and **3-lb/cu. ft. (48-kg/cu. m)** nominal density.
  - c. High-Temperature Mineral-Fiber Board: **3 inches (75 mm)** thick and **3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
2. Round, concealed breeching and connector insulation shall be one of the following:
  - a. Calcium Silicate: **4 inches (100 mm)** thick.
  - b. High-Temperature Mineral-Fiber Blanket: **3 inches (75 mm)** thick and **3-lb/cu. ft. (48-kg/cu. m)** nominal density.
  - c. High-Temperature Mineral-Fiber Board: **3 inches (75 mm)** thick and **3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
3. Rectangular, exposed breeching and connector insulation shall be one of the following:
  - a. Calcium Silicate: **4 inches (100 mm)** thick.
  - b. High-Temperature Mineral-Fiber Blanket: **3 inches (75 mm)** thick and **3-lb/cu. ft. (48-kg/cu. m)** nominal density.
  - c. High-Temperature Mineral-Fiber Board: **3 inches (75 mm)** thick and **3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
4. Rectangular, concealed breeching and connector insulation shall be one of the following:
  - a. Calcium Silicate: **4 inches (100 mm)** thick.
  - b. High-Temperature Mineral-Fiber Blanket: **3 inches (75 mm)** thick and **3-lb/cu. ft. (48-kg/cu. m)** nominal density.
  - c. High-Temperature Mineral-Fiber Board: **3 inches (75 mm)** thick and **3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.

**S. Duct Insulation Schedule, General**

1. Plenums and Ducts Requiring Insulation:
  - a. Indoor, concealed supply and outdoor air.
  - b. Indoor, exposed supply and outdoor air.
  - c. Indoor, concealed return located in nonconditioned space.
  - d. Indoor, exposed return located in nonconditioned space.
  - e. Indoor, concealed, Type I, commercial, kitchen hood exhaust.
  - f. Indoor, exposed, Type I, commercial, kitchen hood exhaust.
  - g. Indoor, concealed oven and warewash exhaust.
  - h. Indoor, exposed oven and warewash exhaust.
  - i. Indoor, concealed exhaust between isolation damper and penetration of building exterior.
  - j. Indoor, exposed exhaust between isolation damper and penetration of building exterior.
  - k. Outdoor, concealed supply and return.
  - l. Outdoor, exposed supply and return.
2. Items Not Insulated:
  - a. Fibrous-glass ducts.
  - b. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
  - c. Factory-insulated flexible ducts.
  - d. Factory-insulated plenums and casings.
  - e. Flexible connectors.
  - f. Vibration-control devices.
  - g. Factory-insulated access panels and doors.

T. Indoor Duct And Plenum Insulation Schedule

1. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.
2. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.
3. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.
4. Concealed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.
5. Concealed, rectangular, supply-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.



6. Concealed, rectangular, return-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm), as directed, thick.
7. Concealed, rectangular, outdoor-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm), as directed, thick.
8. Concealed, rectangular, exhaust-air duct insulation between isolation damper and penetration of building exterior shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.
9. Concealed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket OR board, as directed; thickness as required to achieve 2-hour fire rating.
10. Concealed, supply-air plenum insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.
11. Concealed, return-air plenum insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.

- d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.**
- e. Polyolefin: **1 inch (25 mm) thick.**
12. Concealed, outdoor-air plenum insulation shall be one of the following:
  - a. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.**
  - b. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.**
  - c. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.**
13. Concealed, exhaust-air plenum insulation shall be one of the following:
  - a. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.**
  - b. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.**
  - c. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.**
14. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: **1 inch (25 mm) thick.**
  - b. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.**
  - c. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.**
  - d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.**
  - e. Polyolefin: **1 inch (25 mm) thick.**
15. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: **1 inch (25 mm) thick.**
  - b. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.**
  - c. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.**
  - d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.**
  - e. Polyolefin: **1 inch (25 mm) thick.**
16. Exposed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: **1 inch (25 mm) thick.**
  - b. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.**
  - c. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.**
  - d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.**
  - e. Polyolefin: **1 inch (25 mm) thick.**
17. Exposed, round and flat-oval, exhaust-air duct insulation shall be one of the following:
  - a. Flexible Elastomeric: **1 inch (25 mm) thick.**

- b. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
  - c. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
  - d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  - e. Polyolefin: **1 inch (25 mm)** thick.
18. Exposed, rectangular, supply-air duct insulation shall be one of the following:
- a. Flexible Elastomeric: **1 inch (25 mm)** thick.
  - b. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
  - c. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96 kg/cu. m), as directed**, nominal density.
  - d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  - e. Polyolefin: **1 inch (25 mm)** thick.
19. Exposed, rectangular, return-air duct insulation shall be one of the following:
- a. Flexible Elastomeric: **1 inch (25 mm)** thick.
  - b. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
  - c. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
  - d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  - e. Polyolefin: **1 inch (25 mm)** thick.
20. Exposed, rectangular, outdoor-air duct insulation shall be one of the following:
- a. Flexible Elastomeric: **1 inch (25 mm)** thick.
  - b. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
  - c. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
  - d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  - e. Polyolefin: **1 inch (25 mm)** thick.
21. Exposed, rectangular, exhaust-air duct insulation shall be one of the following:
- a. Flexible Elastomeric: **1 inch (25 mm)** thick.
  - b. Mineral-Fiber Blanket: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
  - c. Mineral-Fiber Board: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
  - d. Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  - e. Polyolefin: **1 inch (25 mm)** thick.
22. Exposed, Type I, Commercial, Kitchen Hood Exhaust Duct and Plenum Insulation: Fire-rated blanket **OR** board, **as directed**; thickness as required to achieve 2-hour fire rating.



23. Exposed, supply-air plenum insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.
24. Exposed, return-air plenum insulation shall be one of the following:
  - a. Flexible Elastomeric: 1 inch (25 mm) thick.
  - b. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - e. Polyolefin: 1 inch (25 mm) thick.
25. Exposed, outdoor-air plenum insulation shall be one of the following:
  - a. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - b. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - c. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
26. Exposed, exhaust-air plenum insulation shall be one of the following:
  - a. Mineral-Fiber Blanket: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
  - b. Mineral-Fiber Board: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - c. Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
- U. Aboveground, Outdoor Duct And Plenum Insulation Schedule
  1. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
  2. Concealed, round and flat-oval, supply-air duct insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: 2 inches (50 mm) OR 3 inches (75 mm), as directed, and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.
    - b. Mineral-Fiber Board: 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
    - c. Phenolic: 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  3. Concealed, round and flat-oval, return-air duct insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: 2 inches (50 mm) OR 3 inches (75 mm), as directed, and 0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed, nominal density.

- b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  4. Concealed, round and flat-oval, outdoor-air duct insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  5. Concealed, rectangular, supply-air duct insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  6. Concealed, rectangular, return-air duct insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  7. Concealed, supply-air plenum insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  8. Concealed, return-air plenum insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  9. Exposed, round and flat-oval, supply-air duct insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  10. Exposed, round and flat-oval, return-air duct insulation shall be one of the following:

- a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
  - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
  - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  11. Exposed, rectangular, supply-air duct insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  12. Exposed, rectangular, return-air duct insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  13. Exposed, supply-air plenum insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
  14. Exposed, return-air plenum insulation shall be one of the following:
    - a. Mineral-Fiber Blanket: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, and **0.75-lb/cu. ft. (12-kg/cu. m) OR 1.5-lb/cu. ft. (24-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m), as directed**, nominal density.
    - b. Mineral-Fiber Board: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - c. Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
- V. Equipment Insulation Schedule
1. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
  2. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
  3. Chillers: Insulate cold surfaces on chillers, including, but not limited to, evaporator bundles, condenser bundles, heat-recovery bundles, suction piping, compressor inlets, tube sheets, water boxes, and nozzles with one of the following:
    - a. Cellular Glass: **2 inches (50 mm)** thick.
    - b. Flexible Elastomeric: **1 inch (25 mm)** thick.
    - c. Mineral-Fiber Board: **1 inch (25 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed**, nominal density.
    - d. Mineral-Fiber Pipe and Tank: **1 inch (25 mm)** thick.
    - e. Phenolic: **1 inch (25 mm)** thick.
    - f. Polyisocyanurate: **1 inch (25 mm)** thick.
    - g. Polyolefin: **1 inch (25 mm)** thick.
  4. Heat-exchanger (water-to-water for cooling service) insulation shall be one of the following:

- a. Cellular Glass: **2 inches (50 mm)** thick.
- b. Flexible Elastomeric: **1 inch (25 mm)** thick.
- c. Mineral-Fiber Board: **1 inch (25 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
- d. Mineral-Fiber Pipe and Tank: **1 inch (25 mm)** thick.
- e. Phenolic: **1 inch (25 mm)** thick.
- f. Polyisocyanurate: **1 inch (25 mm)** thick.
- g. Polyolefin: **1 inch (25 mm)** thick.
5. Heat-exchanger (water-to-water for heating service) insulation shall be one of the following:
  - a. Calcium Silicate: **3 inches (75 mm)** thick.
  - b. Cellular Glass: **3 inches (75 mm)** thick.
  - c. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
  - d. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.
6. Steam-to-hot-water converter insulation shall be one of the following:
  - a. Calcium Silicate: **3 inches (75 mm)** thick.
  - b. Cellular Glass: **3 inches (75 mm)** thick.
  - c. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
  - d. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.
7. Hot-water-to-steam converter insulation shall be one of the following:
  - a. Calcium Silicate: **3 inches (75 mm)** thick.
  - b. Cellular Glass: **3 inches (75 mm)** thick.
  - c. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
  - d. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.
8. Chilled-water pump insulation shall be one of the following:
  - a. Cellular Glass: **3 inches (75 mm)** thick.
  - b. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
  - c. Phenolic: **2 inches (50 mm)** thick.
  - d. Polyisocyanurate: **1-1/2 inches (38 mm)** thick.
9. Condenser-water pump insulation shall be one of the following:
  - a. Cellular Glass: **2 inches (50 mm)** thick.
  - b. Mineral-Fiber Board: **1 inch (25 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
  - c. Phenolic: **1 inch (25 mm)** thick.
  - d. Polyisocyanurate: **1-1/2 inches (38 mm)** thick.
10. Dual-service heating and cooling pump insulation shall be one of the following:
  - a. Cellular Glass: **3 inches (75 mm)** thick.
  - b. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
  - c. Phenolic: **2 inches (50 mm)** thick.
  - d. Polyisocyanurate: **1 inch (25 mm)** thick.
11. Heating-hot-water pump insulation shall be one of the following:
  - a. Calcium Silicate: **3 inches (75 mm)** thick.
  - b. Cellular Glass: **3 inches (75 mm)** thick.
  - c. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
12. Heat-recovery pump insulation shall be one of the following:
  - a. Cellular Glass: **2 inches (50 mm)** thick.
  - b. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
  - c. Phenolic: **1 inch (25 mm)** thick.
  - d. Polyisocyanurate: **1-1/2 inches (38 mm)** thick.



13. Steam condensate pump and boiler feedwater pump insulation shall be one of the following:
- Calcium Silicate: 3 inches (75 mm) thick.
  - Cellular Glass: 3 inches (75 mm) thick.
  - Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
14. Chilled-water expansion/compression tank insulation shall be one of the following:
- Cellular Glass: 1-1/2 inches (38 mm) thick.
  - Flexible Elastomeric: 1 inch (25 mm) thick.
  - Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
  - Phenolic: 1 inch (25 mm) thick.
  - Polyisocyanurate: 1 inch (25 mm) thick.
  - Polyolefin: 1 inch (25 mm) thick.
15. Condenser-water expansion/compression tank insulation shall be one of the following:
- Cellular Glass: 1-1/2 inches (38 mm) thick.
  - Flexible Elastomeric: 1 inch (25 mm) thick.
  - Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
  - Phenolic: 1 inch (25 mm) thick.
  - Polyisocyanurate: 1 inch (25 mm) thick.
  - Polyolefin: 1 inch (25 mm) thick.
16. Dual-service heating and cooling expansion/compression tank insulation shall be one of the following:
- Cellular Glass: 1-1/2 inches (38 mm) thick.
  - Flexible Elastomeric: 1 inch (25 mm) thick.
  - Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
  - Phenolic: 1 inch (25 mm) thick.
  - Polyisocyanurate: 1 inch (25 mm) thick.
  - Polyolefin: 1 inch (25 mm) thick.
17. Heating-hot-water expansion/compression tank insulation shall be one of the following:
- Calcium Silicate: 2 inches (50 mm) thick.
  - Cellular Glass: 1-1/2 inches (38 mm) thick.
  - Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
18. Heat-recovery expansion/compression tank insulation shall be one of the following:
- Cellular Glass: 1-1/2 inches (38 mm) thick.
  - Flexible Elastomeric: 1 inch (25 mm) thick.
  - Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
  - Phenolic: 1 inch (25 mm) thick.
  - Polyisocyanurate: 1 inch (25 mm) thick.
  - Polyolefin: 1 inch (25 mm) thick.
19. Chilled-water air-separator insulation shall be one of the following:
- Cellular Glass: 2 inches (50 mm) thick.
  - Flexible Elastomeric: 1 inch (25 mm) thick.
  - Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
  - Phenolic: 1 inch (25 mm) thick.

- f. Polyisocyanurate: 1 inch (25 mm) thick.
- g. Polyolefin: 1 inch (25 mm) thick.
- 20. Condenser-water air-separator insulation shall be one of the following:
  - a. Cellular Glass: 2 inches (50 mm) thick.
  - b. Flexible Elastomeric: 1 inch (25 mm) thick.
  - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
  - e. Phenolic: 1 inch (25 mm) thick.
  - f. Polyisocyanurate: 1 inch (25 mm) thick.
  - g. Polyolefin: 1 inch (25 mm) thick.
- 21. Dual-service heating and cooling air-separator insulation shall be one of the following:
  - a. Cellular Glass: 2 inches (50 mm) thick.
  - b. Flexible Elastomeric: 1 inch (25 mm) thick.
  - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
  - e. Phenolic: 1 inch (25 mm) thick.
  - f. Polyisocyanurate: 1 inch (25 mm) thick.
  - g. Polyolefin: 1 inch (25 mm) thick.
- 22. Heating-hot-water air-separator insulation shall be one of the following:
  - a. Calcium Silicate: 3 inches (75 mm) thick.
  - b. Cellular Glass: 3 inches (75 mm) thick.
  - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
- 23. Heat-recovery air-separator insulation shall be one of the following:
  - a. Cellular Glass: 2 inches (50 mm) thick.
  - b. Flexible Elastomeric: 1 inch (25 mm) thick.
  - c. Mineral-Fiber Board: 1 inch (25 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Mineral-Fiber Pipe and Tank: 1 inch (25 mm) thick.
  - e. Phenolic: 1 inch (25 mm) thick.
  - f. Polyisocyanurate: 1 inch (25 mm) thick.
  - g. Polyolefin: 1 inch (25 mm) thick.
- 24. Thermal storage tank (brine, water, ice) insulation shall be one of the following:
  - a. Cellular Glass: 4 inches (100 mm) thick.
  - b. Mineral-Fiber Board: 3 inches (75 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - c. Mineral-Fiber Pipe and Tank: 3 inches (75 mm) thick.
  - d. Phenolic: 3 inches (75 mm) thick.
  - e. Polyisocyanurate (Outdoor Application Only): 3 inches (75 mm) thick.
  - f. Polystyrene (Outdoor Application Only): 3 inches (75 mm) thick.
- 25. Deaerator insulation shall be one of the following:
  - a. Calcium Silicate: 3 inches (75 mm) thick.
  - b. Cellular Glass: 3 inches (75 mm) thick.
  - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.
- 26. Steam condensate tank and receiver insulation shall be one of the following:
  - a. Calcium Silicate: 3 inches (75 mm) thick.
  - b. Cellular Glass: 3 inches (75 mm) thick.
  - c. Mineral-Fiber Board: 2 inches (50 mm) thick and 2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m), as directed, nominal density.
  - d. Mineral-Fiber Pipe and Tank: 2 inches (50 mm) thick.

27. Steam flash-tank, flash-separator, and blow-off-tank insulation shall be one of the following:
    - a. Calcium Silicate: **3 inches (75 mm)** thick.
    - b. Cellular Glass: **3 inches (75 mm)** thick.
    - c. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
    - d. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.
  28. Piping system filter-housing insulation shall be one of the following:
    - a. Cellular Glass: **3 inches (75 mm)** thick.
    - b. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
    - c. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.
  29. Outdoor, aboveground, heated, fuel-oil storage tank insulation shall be one of the following:
    - a. Cellular Glass: **3 inches (75 mm)** thick.
    - b. Mineral-Fiber Board: **2 inches (50 mm)** thick and **2-lb/cu. ft. (32-kg/cu. m) OR 3-lb/cu. ft. (48-kg/cu. m) OR 6-lb/cu. ft. (96-kg/cu. m)**, **as directed**, nominal density.
    - c. Mineral-Fiber Pipe and Tank: **2 inches (50 mm)** thick.
    - d. Polyisocyanurate: **1-1/2 inches (38 mm)** thick.
- W. Piping Insulation Schedule, General
1. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
  2. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
    - a. Drainage piping located in crawl spaces.
    - b. Underground piping.
    - c. Chrome-plated pipes and fittings unless there is a potential for personnel injury.
- X. Indoor Piping Insulation Schedule
1. Condensate and Equipment Drain Water below **60 Deg F (16 Deg C)**:
    - a. All Pipe Sizes: Insulation shall be one of the following:
      - 1) Cellular Glass: **1-1/2 inches (38 mm)** thick.
      - 2) Flexible Elastomeric: **3/4 inch (19 mm) OR 1 inch (25 mm)**, **as directed**, thick.
      - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: **1/2 inch (13 mm) OR 1 inch (25 mm)**, **as directed**, thick.
      - 4) Phenolic: **1 inch (25 mm)** thick.
      - 5) Polyisocyanurate: **1 inch (25 mm)** thick.
      - 6) Polyolefin: **3/4 inch (19 mm) OR 1 inch (25 mm)**, **as directed**, thick.
  2. Chilled Water and Brine, **40 Deg F (5 Deg C)** and below:
    - a. **NPS 3 (DN 80)** and Smaller: Insulation shall be one of the following:
      - 1) Cellular Glass: **1-1/2 inches (38 mm) OR 2 inches (50 mm)**, **as directed**, thick.
      - 2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm)**, **as directed**, thick.
      - 3) Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm)**, **as directed**, thick.
      - 4) Polyisocyanurate: **1 inch (25 mm) OR 1-1/2 inches (38 mm)**, **as directed**, thick.
    - b. **NPS 4 (DN 100) to NPS 12 (DN 300)**: Insulation shall be one of the following:
      - 1) Cellular Glass: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm)**, **as directed**, thick.
      - 2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed**: **1-1/2 inches (38 mm) OR 2 inches (50 mm)**, **as directed**, thick.
      - 3) Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm)**, **as directed**, thick.
      - 4) Polyisocyanurate: **1 inch (25 mm) OR 1-1/2 inches (38 mm)**, **as directed**, thick.
    - c. **NPS 14 (DN 350)** and Larger: Insulation shall be one of the following:
      - 1) Cellular Glass: **2 inches (50 mm) OR 3 inches (75 mm)**, **as directed**, thick.



- 2) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed: 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
  - 3) Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
  - 4) Polyisocyanurate: **1-1/2 inches (38 mm)** thick.
3. Chilled Water and Brine, above **40 Deg F (5 Deg C)**:
- a. **NPS 12 (DN 300)** and Smaller: Insulation shall be one of the following:
    - 1) Cellular Glass: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
    - 2) Flexible Elastomeric: **1 inch (25 mm)** thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
    - 4) Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 5) Polyisocyanurate: **1 inch (25 mm) OR 1-1/2 inches (38 mm), as directed**, thick.
    - 6) Polyolefin: **1 inch (25 mm)** thick.
  - b. **NPS 14 (DN 350)** and Larger: Insulation shall be one of the following:
    - 1) Cellular Glass: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 2) Mineral-Fiber Preformed Pipe, Type I **OR** Pipe Insulation Wicking System, **as directed: 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 3) Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 4) Polyisocyanurate: **1-1/2 inches (38 mm)** thick.
4. Condenser-Water Supply and Return:
- a. **NPS 12 (DN 300)** and Smaller: Insulation shall be one of the following:
    - 1) Cellular Glass: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
    - 2) Flexible Elastomeric: **1 inch (25 mm)** thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
    - 4) Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm), as directed**, thick.
    - 5) Polyisocyanurate: **1 inch (25 mm) OR 1-1/2 inches (38 mm), as directed**, thick.
    - 6) Polyolefin: **1 inch (25 mm)** thick.
  - b. **NPS 14 (DN 350)** and Larger: Insulation shall be one of the following:
    - 1) Cellular Glass: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 2) Mineral-Fiber, Preformed Pipe, Type I: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 3) Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 4) Polyisocyanurate: **1-1/2 inches (38 mm)** thick.
5. Heating-Hot-Water Supply and Return, **200 Deg F (93 Deg C)** and below:
- a. **NPS 12 (DN 300)** and Smaller: Insulation shall be one of the following:
    - 1) Cellular Glass: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, thick.
    - 2) Mineral-Fiber, Preformed Pipe, Type I: **1 inch (25 mm) OR 2 inches (50 mm), as directed**, thick.
    - 3) Phenolic: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 4) Polyisocyanurate: **1 inch (25 mm) OR 1-1/2 inches (38 mm), as directed**, thick.
  - b. **NPS 14 (DN 350)** and Larger: Insulation shall be one of the following:
    - 1) Cellular Glass: **2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 2) Mineral-Fiber, Preformed Pipe, Type I: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 3) Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
    - 4) Polyisocyanurate: **1-1/2 inches (38 mm)** thick.

6. Heating-Hot-Water Supply and Return, above 200 Deg F (93 Deg C):
  - a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
    - 1) Calcium Silicate: 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick.
    - 2) Cellular Glass: 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
    - 1) Calcium Silicate: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
    - 2) Cellular Glass: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
7. Steam and Steam Condensate, 350 Deg F (177 Deg C) and below:
  - a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
    - 1) Calcium Silicate: 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick.
    - 2) Cellular Glass: 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
    - 1) Calcium Silicate: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
    - 2) Cellular Glass: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
8. Steam and Steam Condensate, above 350 Deg F (177 Deg C):
  - a. NPS 3/4 (DN 20) and Smaller: Insulation shall be one of the following:
    - 1) Calcium Silicate: 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick.
    - 2) Cellular Glass: 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
  - b. NPS 1 (DN 25) and Larger: Insulation shall be one of the following:
    - 1) Calcium Silicate: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
    - 2) Cellular Glass: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I or II: 3 inches (75 mm) OR 4 inches (100 mm), as directed, thick.
9. Refrigerant Suction and Hot-Gas Piping:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Cellular Glass: 1-1/2 inches (38 mm) thick.
    - 2) Flexible Elastomeric: 1 inch (25 mm) thick.
    - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
    - 4) Phenolic: 1 inch (25 mm) thick.
    - 5) Polyisocyanurate: 1 inch (25 mm) thick.
    - 6) Polyolefin: 1 inch (25 mm) thick.
10. Refrigerant Suction and Hot-Gas Flexible Tubing:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Flexible Elastomeric: 1 inch (25 mm) thick.
    - 2) Polyolefin: 1 inch (25 mm) thick.
11. Dual-Service Heating and Cooling, 40 to 200 Deg F (5 to 93 Deg C):
  - a. NPS 12 (DN 300) and Smaller: Insulation shall be one of the following:
    - 1) Cellular Glass: 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
    - 2) Mineral-Fiber, Preformed Pipe, Type I: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed, thick.
    - 3) Phenolic: 1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick.
    - 4) Polyisocyanurate: 1 inch (25 mm) OR 1-1/2 inches (38 mm), as directed, thick.
  - b. NPS 14 (DN 350) and Larger: Insulation shall be one of the following:
    - 1) Cellular Glass: 2 inches (50 mm) OR 3 inches (75 mm), as directed, thick.

- 2) Mineral-Fiber, Preformed Pipe, Type I: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
  - 3) Phenolic: **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**, thick.
  - 4) Polyisocyanurate: **1-1/2 inches (38 mm)** thick.
12. Heat-Recovery Piping:
- a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Cellular Glass: **1-1/2 inches (38 mm)** thick.
    - 2) Flexible Elastomeric: **1 inch (25 mm)** thick.
    - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: **1 inch (25 mm)** thick.
    - 4) Phenolic: **1 inch (25 mm)** thick.
    - 5) Polyisocyanurate: **1 inch (25 mm)** thick.
    - 6) Polyolefin: **1 inch (25 mm)** thick.
13. Hot Service Drains:
- a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Calcium Silicate: **1-1/2 inches (38 mm)** thick.
    - 2) Cellular Glass: **1-1/2 inches (38 mm)** thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I or II: **1 inch (25 mm)** thick.
14. Hot Service Vents:
- a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Calcium Silicate: **1-1/2 inches (38 mm)** thick.
    - 2) Cellular Glass: **1-1/2 inches (38 mm)** thick.
    - 3) Mineral-Fiber, Preformed Pipe, Type I or II: **1 inch (25 mm)** thick.
- Y. Outdoor, Aboveground Piping Insulation Schedule
1. Chilled Water and Brine:
    - a. All Pipe Sizes: Insulation shall be one of the following:
      - 1) Cellular Glass: **3 inches (75 mm)** thick.
      - 2) Flexible Elastomeric: **3 inches (75 mm)** thick.
      - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: **3 inches (75 mm)** thick.
      - 4) Phenolic: **2 inches (50 mm)** thick.
      - 5) Polyisocyanurate: **2 inches (50 mm)** thick.
      - 6) Polyolefin: **3 inches (75 mm)** thick.
      - 7) Polystyrene: **2 inches (50 mm)** thick.
  2. Condenser-Water Supply and Return:
    - a. All Pipe Sizes: Insulation shall be one of the following:
      - 1) Cellular Glass: **2 inches (50 mm)** thick.
      - 2) Flexible Elastomeric: **2 inches (50 mm)** thick.
      - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: **2 inches (50 mm)** thick.
      - 4) Phenolic: **2 inches (50 mm)** thick.
      - 5) Polyisocyanurate: **2 inches (50 mm)** thick.
      - 6) Polyolefin: **2 inches (50 mm)** thick.
      - 7) Polystyrene: **2 inches (50 mm)** thick.
  3. Heating-Hot-Water Supply and Return, **200 Deg F (93 Deg C)** and below:
    - a. All Pipe Sizes: Insulation shall be one of the following:
      - 1) Cellular Glass: **3 inches (75 mm)** thick.
      - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: **2 inches (50 mm)** thick.
      - 3) Phenolic: **2 inches (50 mm)** thick.
      - 4) Polyisocyanurate: **2 inches (50 mm)** thick.
  4. Heating-Hot-Water Supply and Return, above **200 Deg F (93 Deg C)**:
    - a. All Pipe Sizes: Insulation shall be one of the following:
      - 1) Calcium Silicate: **3 inches (75 mm)** thick.
      - 2) Cellular Glass: **3 inches (75 mm)** thick.
      - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: **2 inches (50 mm)** thick.
  5. Steam and Steam Condensate, **350 Deg F (177 Deg C)** and below:

- a. All Pipe Sizes: Insulation shall be one of the following:
  - 1) Calcium Silicate: 4 inches (100 mm) thick.
  - 2) Cellular Glass: 4 inches (100 mm) thick.
  - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: 3 inches (75 mm) thick.
6. Steam and Steam Condensate, above 350 Deg F (177 Deg C):
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Calcium Silicate: 5 inches (125 mm) thick.
    - 2) Cellular Glass: 5 inches (125 mm) thick.
    - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I or II: 4 inches (100 mm) thick.
7. Refrigerant Suction and Hot-Gas Piping:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Cellular Glass: 2 inches (50 mm) thick.
    - 2) Flexible Elastomeric: 2 inches (50 mm) thick.
    - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
    - 4) Phenolic: 2 inches (50 mm) thick.
    - 5) Polyisocyanurate: 2 inches (50 mm) thick.
    - 6) Polyolefin: 2 inches (50 mm) thick.
    - 7) Polystyrene: 2 inches (50 mm) thick.
8. Refrigerant Suction and Hot-Gas Flexible Tubing:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Flexible Elastomeric: 2 inches (50 mm) thick.
    - 2) Polyolefin: 2 inches (50 mm) thick.
9. Heat-Recovery Piping:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Cellular Glass: 2 inches (50 mm) thick.
    - 2) Flexible Elastomeric: 2 inches (50 mm) thick.
    - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
    - 4) Phenolic: 2 inches (50 mm) thick.
    - 5) Polyisocyanurate: 2 inches (50 mm) thick.
    - 6) Polyolefin: 2 inches (50 mm) thick.
    - 7) Polystyrene: 2 inches (50 mm) thick.
10. Dual-Service Heating and Cooling:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Cellular Glass: 3 inches (75 mm) thick.
    - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
    - 3) Phenolic: 2 inches (50 mm) thick.
    - 4) Polyisocyanurate: 2 inches (50 mm) thick.
11. Hot Service Drains:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
    - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
    - 3) Mineral-Fiber, Preformed Pipe Insulation, Type I: 1 inch (25 mm) thick.
12. Hot Service Vents:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Calcium Silicate: 1-1/2 inches (38 mm) thick.
    - 2) Cellular Glass: 1-1/2 inches (38 mm) thick.
    - 3) Mineral-Fiber, Preformed Pipe Insulation, Type II: 1 inch (25 mm) thick.
13. Fuel Oil Piping, Heated:
  - a. All Pipe Sizes: Insulation shall be one of the following:
    - 1) Cellular Glass: 2 inches (50 mm) thick.
    - 2) Mineral-Fiber, Preformed Pipe Insulation, Type I: 2 inches (50 mm) thick.
- Z. Outdoor, Underground Piping Insulation Schedule
  1. Loose-fill insulation, for belowground piping, is specified in Division 28.
  2. Chilled Water, All Sizes: Cellular glass, 2 inches (50 mm) thick.
  3. Condenser-Water Supply and Return, All Sizes: Cellular glass, 2 inches (50 mm) thick.



4. Heating-Hot-Water Supply and Return, All Sizes, **200 Deg F (93 Deg C)** and below: Cellular glass, **3 inches (75 mm)** thick.
  5. Heating-Hot-Water Supply and Return, All Sizes, above **200 Deg F (93 Deg C)**:
    - a. Calcium Silicate: **3 inches (75 mm)** thick.
    - b. Cellular Glass: **3 inches (75 mm)** thick.
  6. Steam and Steam Condensate, All Sizes, **350 Deg F (177 Deg C)** and below:
    - a. Calcium Silicate: **4 inches (100 mm)** thick.
    - b. Cellular Glass: **4 inches (100 mm)** thick.
  7. Steam and Steam Condensate, All Sizes, above **350 Deg F (177 Deg C)**:
    - a. Calcium Silicate: **5 inches (125 mm)** thick.
    - b. Cellular Glass: **5 inches (125 mm)** thick.
  8. Dual-Service Heating and Cooling, All Sizes, **40 to 200 Deg F (4 to 93 Deg C)**: Cellular glass, **3 inches (75 mm)** thick.
  9. Fuel Oil Piping, All Sizes, Heated: Cellular glass, **2 inches (50 mm)** thick.
- AA. Indoor, Field-Applied Jacket Schedule
1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
  2. If more than one material is listed, selection from materials listed is Contractor's option.
  3. Ducts and Plenums, Concealed:
    - a. None.
    - b. PVC **OR** PVC, Color-Coded by System, **as directed: 20 mils (0.5 mm) OR 30 mils (0.8 mm), as directed**, thick.
    - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed: 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm) OR 0.040 inch (1.0 mm), as directed**, thick.
    - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed: 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm), as directed**, thick.
    - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed: 0.010 inch (0.25 mm) OR 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm), as directed**, thick.
  4. Ducts and Plenums, Exposed:
    - a. None.
    - b. PVC **OR** PVC, Color-Coded by System, **as directed: 20 mils (0.5 mm) OR 30 mils (0.8 mm), as directed**, thick.
    - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed: 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm) OR 0.040 inch (1.0 mm), as directed**, thick.
    - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed: 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm), as directed**, thick.
    - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed: 0.010 inch (0.25 mm) OR 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm), as directed**, thick.
  5. Equipment, Concealed:
    - a. None.
    - b. PVC **OR** PVC, Color-Coded by System, **as directed: 20 mils (0.5 mm) OR 30 mils (0.8 mm), as directed**, thick.
    - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed: 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm) OR 0.040 inch (1.0 mm), as directed**, thick.
    - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed: 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm), as directed**, thick.

- e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
  - a. None.
  - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
  - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
  - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
  - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Equipment, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
  - a. None.
  - b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
  - c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
8. Piping, Concealed:
  - a. None.
  - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
  - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
  - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
  - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
9. Piping, Exposed:
  - a. None.
  - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
  - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
  - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
  - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.

BB. Outdoor, Field-Applied Jacket Schedule

1. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
2. If more than one material is listed, selection from materials listed is Contractor's option.
3. Ducts and Plenums, Concealed:
  - a. None.
  - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
  - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
  - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
  - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
4. Ducts and Plenums, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
  - a. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
  - b. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
  - c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
5. Ducts and Plenums, Exposed, Larger Than 48 Inches (1200 mm) in Diameter or with Flat Surfaces Larger Than 72 Inches (1800 mm):
  - a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
  - b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with 1-1/4-Inch- (32-mm-) Deep Corrugations **OR** 2-1/2-Inch- (65-mm-) Deep Corrugations **OR** 4-by-1-Inch (100-by-25-mm) Box Ribs, **as directed**: 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
6. Equipment, Concealed:
  - a. None.
  - b. PVC **OR** PVC, Color-Coded by System, **as directed**: 20 mils (0.5 mm) **OR** 30 mils (0.8 mm), **as directed**, thick.
  - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm) **OR** 0.040 inch (1.0 mm), **as directed**, thick.
  - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm) **OR** 0.032 inch (0.81 mm), **as directed**, thick.
  - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: 0.010 inch (0.25 mm) **OR** 0.016 inch (0.41 mm) **OR** 0.020 inch (0.51 mm) **OR** 0.024 inch (0.61 mm), **as directed**, thick.
7. Equipment, Exposed, up to 48 Inches (1200 mm) in Diameter or with Flat Surfaces up to 72 Inches (1800 mm):
  - a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: 0.016 inch (0.41 mm)



- OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm) OR 0.040 inch (1.0 mm), as directed, thick.**
- b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed** with Z-Shaped Locking Seam, **as directed**: **0.010 inch (0.25 mm) OR 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm), as directed, thick.**
8. Equipment, Exposed, Larger Than **48 Inches (1200 mm)** in Diameter or with Flat Surfaces Larger Than **72 Inches (1800 mm)**:
- a. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with **1-1/4-Inch- (32-mm-) Deep Corrugations OR 2-1/2-Inch- (65-mm-) Deep Corrugations OR 4-by-1-Inch (100-by-25-mm) Box Ribs, as directed: 0.032 inch (0.81 mm) OR 0.040 inch (1.0 mm), as directed, thick.**
  - b. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth **OR** Stucco Embossed, **as directed**, with **1-1/4-Inch- (32-mm-) Deep Corrugations OR 2-1/2-Inch- (65-mm-) Deep Corrugations OR 4-by-1-Inch (100-by-25-mm) Box Ribs, as directed: 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm), as directed, thick.**
9. Piping, Concealed:
- a. None.
  - b. PVC **OR** PVC, Color-Coded by System, **as directed**: **20 mils (0.5 mm) OR 30 mils (0.8 mm), as directed, thick.**
  - c. Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: **0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm) OR 0.040 inch (1.0 mm), as directed, thick.**
  - d. Painted Aluminum, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**: **0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm), as directed, thick.**
  - e. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**: **0.010 inch (0.25 mm) OR 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm), as directed, thick.**
10. Piping, Exposed:
- a. PVC: **20 mils (0.5 mm) OR 30 mils (0.8 mm) OR 40 mils (1.0 mm), as directed, thick.**
  - b. Aluminum **OR** Painted Aluminum, **as directed**, Smooth **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: **0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm) OR 0.032 inch (0.81 mm) OR 0.040 inch (1.0 mm), as directed, thick.**
  - c. Stainless Steel, Type 304 **OR** Type 316, **as directed**, Smooth 2B Finish **OR** Corrugated **OR** Stucco Embossed, **as directed**, with Z-Shaped Locking Seam, **as directed**: **0.010 inch (0.25 mm) OR 0.016 inch (0.41 mm) OR 0.020 inch (0.51 mm) OR 0.024 inch (0.61 mm), as directed, thick.**
- CC. Underground, Field-Installed Insulation Jacket
- 1. For underground direct-buried piping applications, install underground direct-buried jacket over insulation material.

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Task	Specification	Specification Description
23 07 16 00	23 07 13 00	HVAC Insulation

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## SECTION 23 09 00 00 - HVAC INSTRUMENTATION AND CONTROLS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC instrumentation and controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes control equipment for HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.

#### C. Definitions

1. DDC: Direct digital control.
2. I/O: Input/output.
3. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
4. MS/TP: Master slave/token passing.
5. PC: Personal computer.
6. PID: Proportional plus integral plus derivative.
7. RTD: Resistance temperature detector.

#### D. System Performance

1. Comply with the following performance requirements:
  - a. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
  - b. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
  - c. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
  - d. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
  - e. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
  - f. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
  - g. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
  - h. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
    - 1) Water Temperature: Plus or minus 1 deg F (0.5 deg C).
    - 2) Water Flow: Plus or minus 5 percent of full scale.
    - 3) Water Pressure: Plus or minus 2 percent of full scale.
    - 4) Space Temperature: Plus or minus 1 deg F (0.5 deg C).
    - 5) Ducted Air Temperature: Plus or minus 1 deg F (0.5 deg C).
    - 6) Outside Air Temperature: Plus or minus 2 deg F (1.0 deg C).
    - 7) Dew Point Temperature: Plus or minus 3 deg F (1.5 deg C).
    - 8) Temperature Differential: Plus or minus 0.25 deg F (0.15 deg C).
    - 9) Relative Humidity: Plus or minus 5 percent.
    - 10) Airflow (Pressurized Spaces): Plus or minus 3 percent of full scale.
    - 11) Airflow (Measuring Stations): Plus or minus 5 percent of full scale.
    - 12) Airflow (Terminal): Plus or minus 10 percent of full scale.



- 13) Air Pressure (Space): Plus or minus 0.01-inch wg (2.5 Pa).
- 14) Air Pressure (Ducts): Plus or minus 0.1-inch wg (25 Pa).
- 15) Carbon Monoxide: Plus or minus 5 percent of reading.
- 16) Carbon Dioxide: Plus or minus 50 ppm.
- 17) Electrical: Plus or minus 5 percent of reading.

#### E. Submittals

1. Product Data: Include manufacturer's technical literature for each control device. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes for materials, and installation and startup instructions for each type of product indicated.
  - a. DDC System Hardware: Bill of materials of equipment indicating quantity, manufacturer, and model number. Include technical data for operator workstation equipment, interface equipment, control units, transducers/transmitters, sensors, actuators, valves, relays/switches, control panels, and operator interface equipment.
  - b. Control System Software: Include technical data for operating system software, operator interface, color graphics, and other third-party applications.
  - c. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - a. Bill of materials of equipment indicating quantity, manufacturer, and model number.
  - b. Schematic flow diagrams showing fans, pumps, coils, dampers, valves, and control devices.
  - c. Wiring Diagrams: Power, signal, and control wiring.
  - d. Details of control panel faces, including controls, instruments, and labeling.
  - e. Written description of sequence of operation.
  - f. Schedule of dampers including size, leakage, and flow characteristics.
  - g. Schedule of valves including flow characteristics.
  - h. DDC System Hardware:
    - 1) Wiring diagrams for control units with termination numbers.
    - 2) Schematic diagrams and floor plans for field sensors and control hardware.
    - 3) Schematic diagrams for control, communication, and power wiring, showing trunk data conductors and wiring between operator workstation and control unit locations.
  - i. Control System Software: List of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
  - j. Controlled Systems:
    - 1) Schematic diagrams of each controlled system with control points labeled and control elements graphically shown, with wiring.
    - 2) Scaled drawings showing mounting, routing, and wiring of elements including bases and special construction.
    - 3) Written description of sequence of operation including schematic diagram.
    - 4) Points list.
3. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with ASHRAE 135.
4. Data Communications Protocol Certificates: Certify that each proposed DDC system component complies with LonWorks.
5. Software and Firmware Operational Documentation: Include the following:
  - a. Software operating and upgrade manuals.
  - b. Program Software Backup: On a magnetic media or compact disc, complete with data files.
  - c. Device address list.
  - d. Printout of software application and graphic screens.
  - e. Software license required by and installed for DDC workstations and control systems.

6. Software Upgrade Kit: For the Owner to use in modifying software to suit future systems revisions or monitoring and control revisions.
7. Field quality-control test reports.
8. Operation and maintenance data.

F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with ASHRAE 135 for DDC system components.

G. Delivery, Storage, And Handling

1. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
2. System Software: Update to latest version of software at Project completion.

## 1.2 PRODUCTS

A. Control System

1. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.
2. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, accessories, and software connected to distributed controllers operating in multiuser, multitasking environment on token-passing network and programmed to control mechanical systems. An operator workstation permits interface with the network via dynamic color graphics with each mechanical system, building floor plan, and control device depicted by point-and-click graphics.
3. Control system shall include the following:
  - a. Building intrusion detection system specified in Division 28 Section "Intrusion Detection".
  - b. Building clock control system specified in Division 27 Section "Clock Systems".
  - c. Building lighting control system specified in Division 26 Section "Network Lighting Controls".
  - d. Fire alarm system specified in Division 28 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System", **as directed**.

B. DDC Equipment

1. Operator Workstation: One **OR** Two, **as directed**, PC-based microcomputer(s) with minimum configuration as follows:
  - a. Motherboard: With 8 integrated USB 2.0 ports, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.
  - b. Processor: Intel Pentium 4, **<Insert clock speed>** MHz.
  - c. Random-Access Memory: 512 MB.
  - d. Graphics: Video adapter, minimum 1280 x 1024 **OR** 1600 x 1200, **as directed**, pixels, 64-MB video memory, with TV out.
  - e. Monitor: **17 inches (430 mm) OR 19 inches (480 mm)**, **as directed**, LCD color.
  - f. Keyboard: QWERTY, 105 keys in ergonomic shape.
  - g. Floppy-Disk Drive: 1.44 MB.
  - h. Hard-Disk Drive: 80 GB.
  - i. CD-ROM Read/Write Drive: 48x24x48.
  - j. Mouse: Three button, optical.
  - k. Uninterruptible Power Supply: 2 kVa.
  - l. Operating System: Microsoft Windows XP Professional with high-speed Internet access.
    - 1) ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.



- 2) LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
- m. Printer: Black-and-white, laser-jet type as follows:
  - 1) Print Head: 1200 x 1200 dpi resolution.
  - 2) Paper Handling: Minimum of 250 sheet trays.
  - 3) Print Speed: Minimum of 120 characters per second.
- n. Printer: Color, ink-jet type as follows:
  - 1) Print Head: 4800 x 1200 dpi optimized color resolution.
  - 2) Paper Handling: Minimum of 100 sheets.
  - 3) Print Speed: Minimum of 17 ppm in black and 12 ppm in color.
- o. Application Software:
  - 1) I/O capability from operator station.
  - 2) System security for each operator via software password and access levels.
  - 3) Automatic system diagnostics; monitor system and report failures.
  - 4) Database creation and support.
  - 5) Automatic and manual database save and restore.
  - 6) Dynamic color graphic displays with up to 10 screen displays at once.
  - 7) Custom graphics generation and graphics library of HVAC equipment and symbols.
  - 8) Alarm processing, messages, and reactions.
  - 9) Trend logs retrievable in spreadsheets and database programs.
  - 10) Alarm and event processing.
  - 11) Object and property status and control.
  - 12) Automatic restart of field equipment on restoration of power.
  - 13) Data collection, reports, and logs. Include standard reports for the following:
    - a) Current values of all objects.
    - b) Current alarm summary.
    - c) Disabled objects.
    - d) Alarm lockout objects.
    - e) Logs.
  - 14) Custom report development.
  - 15) Utility and weather reports.
  - 16) Workstation application editors for controllers and schedules.
  - 17) Maintenance management.
- p. Custom Application Software:
  - 1) English language oriented.
  - 2) Full-screen character editor/programming environment.
  - 3) Allow development of independently executing program modules with debugging/simulation capability.
  - 4) Support conditional statements.
  - 5) Support floating-point arithmetic with mathematic functions.
  - 6) Contains predefined time variables.
2. Diagnostic Terminal Unit: Portable notebook-style, PC-based microcomputer terminal capable of accessing system data by connecting to system network with minimum configuration as follows:
  - a. System: With one integrated USB 2.0 port, integrated Intel Pro 10/100 (Ethernet), integrated audio, bios, and hardware monitoring.
  - b. Processor: Intel Pentium 4, **<Insert clock speed>** MHz.
  - c. Random-Access Memory: 128 MB.
  - d. Graphics: Video adapter, minimum 800 x 600 **OR** 1024 x 768, **as directed**, pixels, 64-MB video memory.
  - e. Monitor: **17 inches (430 mm) OR 19 inches (480 mm)**, **as directed**, LCD color.
  - f. Keyboard: QWERTY 105 keys in ergonomic shape.
  - g. Floppy-Disk Drive: 1.44 MB.
  - h. Hard-Disk Drive: 800 MB.
  - i. CD-ROM Read/Write Drive: 48x24x48.
  - j. Pointing Device: Touch pad or other internal device.

3. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.
  - a. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
  - b. Stand-alone mode control functions operate regardless of network status. Functions include the following:
    - 1) Global communications.
    - 2) Discrete/digital, analog, and pulse I/O.
    - 3) Monitoring, controlling, or addressing data points.
    - 4) Software applications, scheduling, and alarm processing.
    - 5) Testing and developing control algorithms without disrupting field hardware and controlled environment.
  - c. Standard Application Programs:
    - 1) Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
    - 2) HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
    - 3) Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
    - 4) Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
    - 5) Remote communications.
    - 6) Maintenance management.
    - 7) Units of Measure: Inch-pound and SI (metric).
  - d. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
  - e. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
  - f. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
4. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.
  - a. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
  - b. Stand-alone mode control functions operate regardless of network status. Functions include the following:
    - 1) Global communications.
    - 2) Discrete/digital, analog, and pulse I/O.
    - 3) Monitoring, controlling, or addressing data points.
  - c. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
  - d. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
  - e. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
5. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.
  - a. Binary Inputs: Allow monitoring of on-off signals without external power.
  - b. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
  - c. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.

- d. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation with three-position (on-off-auto) override switches and status lights, **as directed**.
- e. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA) with status lights, two-position (auto-manual) switch, and manually adjustable potentiometer, **as directed**.
- f. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
- g. Universal I/Os: Provide software selectable binary or analog outputs.
- 6. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:
  - a. Output ripple of 5.0 mV maximum peak to peak.
  - b. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
  - c. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.
- 7. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:
  - a. Minimum dielectric strength of 1000 V.
  - b. Maximum response time of 10 nanoseconds.
  - c. Minimum transverse-mode noise attenuation of 65 dB.
  - d. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

#### C. Unitary Controllers

- 1. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.
  - a. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
  - b. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock, **as directed**. Perform automatic system diagnostics; monitor system and report failures.
  - c. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
  - d. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.
  - e. Enclosure: Dustproof rated for operation at 32 to 120 deg F (0 to 50 deg C).
  - f. Enclosure: Waterproof rated for operation at 40 to 150 deg F (5 to 65 deg C).

#### D. Alarm Panels

- 1. Unitized cabinet with suitable brackets for wall or floor mounting. Fabricate of 0.06-inch- (1.5-mm-) thick, furniture-quality steel or extruded-aluminum alloy, totally enclosed, with hinged doors and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels, **as directed**.
- 2. Indicating light for each alarm point, single horn, acknowledge switch, and test switch, mounted on hinged cover.
  - a. Alarm Condition: Indicating light flashes and horn sounds.
  - b. Acknowledge Switch: Horn is silent and indicating light is steady.
  - c. Second Alarm: Horn sounds and indicating light is steady.
  - d. Alarm Condition Cleared: System is reset and indicating light is extinguished.
  - e. Contacts in alarm panel allow remote monitoring by independent alarm company.

E. Analog Controllers

1. Step Controllers: 6- or 10-stage type, with heavy-duty switching rated to handle loads and operated by electric motor.
2. Electric, Outdoor-Reset Controllers: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range, adjustable set point, scale range **minus 10 to plus 70 deg F (minus 23 to plus 21 deg C)**, and single- or double-pole contacts.
3. Electronic Controllers: Wheatstone-bridge-amplifier type, in steel enclosure with provision for remote-resistance readjustment. Identify adjustments on controllers, including proportional band and authority.
  - a. Single controllers can be integral with control motor if provided with accessible control readjustment potentiometer.
4. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed from maximum to minimum of 55 percent and on-off action below minimum fan speed. Controller shall briefly apply full voltage, when motor is started, to rapidly bring motor up to minimum speed. Equip with filtered circuit to eliminate radio interference.
5. Receiver Controllers: Single- or multiple-input models with control-point adjustment, direct or reverse acting with mechanical set-point adjustment with locking device, proportional band adjustment, authority adjustment, and proportional control mode.
  - a. Remote-control-point adjustment shall be plus or minus 20 percent of sensor span, input signal of **3 to 13 psig (21 to 90 kPa)**.
  - b. Proportional band shall extend from 2 to 20 percent for **5 psig (35 kPa)**.
  - c. Authority shall be 20 to 200 percent.
  - d. Air-supply pressure of **18 psig (124 kPa)**, input signal of **3 to 15 psig (21 to 103 kPa)**, and output signal of zero to supply pressure.
  - e. Gages: **1-1/2 inches (38 mm) OR 2-1/2 inches (64 mm) OR 3-1/2 inches (89 mm)**, **as directed**, in diameter, 2.5 percent wide-scale accuracy, and range to match transmitter input or output pressure.

F. Time Clocks

1. Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.
2. Solid-state, programmable time control with 4 **OR 8, as directed**, separate programs each with up to 100 on-off operations; 1-second resolution; lithium battery backup; keyboard interface and manual override; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; system fault alarm; and communications package allowing networking of time controls and programming from PC.

G. Electronic Sensors

1. Description: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
2. Thermistor Temperature Sensors and Transmitters:
  - a. Accuracy: Plus or minus **0.5 deg F (0.3 deg C) OR 0.36 deg F (0.2 deg C)**, **as directed**, at calibration point.
  - b. Wire: Twisted, shielded-pair cable.
  - c. Insertion Elements in Ducts: Single point, **8 inches (200 mm) OR 18 inches (460 mm)**, **as directed**, long; use where not affected by temperature stratification or where ducts are smaller than **9 sq. ft. (0.84 sq. m)**.
  - d. Averaging Elements in Ducts: **36 inches (915 mm)** long, flexible **OR 72 inches (1830 mm)** long, flexible **OR 18 inches (460 mm)** long, rigid, **as directed**; use where prone to temperature stratification or where ducts are larger than **10 sq. ft. (1 sq. m)**.
  - e. Insertion Elements for Liquids: Brass or stainless-steel socket with minimum insertion length of **2-1/2 inches (64 mm)**.
  - f. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    - 1) Set-Point Adjustment: Concealed **OR Exposed, as directed**.
    - 2) Set-Point Indication: Concealed **OR Keyed OR Exposed, as directed**.

- 3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
- 4) Color: As selected from manufacturer's full range.
- 5) Orientation: Vertical **OR** Horizontal, **as directed**.
- g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
- h. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
3. RTDs and Transmitters:
  - a. Accuracy: Plus or minus 0.2 percent at calibration point.
  - b. Wire: Twisted, shielded-pair cable.
  - c. Insertion Elements in Ducts: Single point, **8 inches (200 mm) OR 18 inches (460 mm), as directed**, long; use where not affected by temperature stratification or where ducts are smaller than **9 sq. ft. (0.84 sq. m)**.
  - d. Averaging Elements in Ducts: **18 inches (460 mm)** long, rigid **OR 24 inches (610 mm)** long, rigid **OR 48 inches (1200 mm)** long, rigid **OR 24 feet (7.3 m)** long, flexible, **as directed**; use where prone to temperature stratification or where ducts are larger than **9 sq. ft. (0.84 sq. m)**; length as required.
  - e. Insertion Elements for Liquids: Brass socket with minimum insertion length of **2-1/2 inches (64 mm)**.
  - f. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    - 1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
    - 2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
    - 3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
    - 4) Color: As selected from manufacturer's full range.
    - 5) Orientation: Vertical **OR** Horizontal, **as directed**.
  - g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
  - h. Room Security Sensors: Stainless-steel cover plate with insulated back and security screws.
4. Humidity Sensors: Bulk polymer sensor element.
  - a. Accuracy: **5 OR 2, as directed**, percent full range with linear output.
  - b. Room Sensor Range: 20 to 80 percent relative humidity.
  - c. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    - 1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
    - 2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
    - 3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
    - 4) Color: As selected from manufacturer's full range.
    - 5) Orientation: Vertical **OR** Horizontal, **as directed**.
  - d. Duct Sensor: 20 to 80 percent relative humidity range with element guard and mounting plate.
  - e. Outside-Air Sensor: 20 to 80 percent relative humidity range with mounting enclosure, suitable for operation at outdoor temperatures of **32 to 120 deg F (0 to 50 deg C) OR minus 22 to plus 185 deg F (minus 30 to plus 85 deg C) OR minus 40 to plus 170 deg F (minus 40 to plus 76 deg C), as directed**.
  - f. Duct and Sensors: With element guard and mounting plate, range of 0 to 100 percent relative humidity.
5. Pressure Transmitters/Transducers:
  - a. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
    - 1) Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
    - 2) Output: 4 to 20 mA.
    - 3) Building Static-Pressure Range: **0- to 0.25-inch wg (0 to 62 Pa)**.
    - 4) Duct Static-Pressure Range: **0- to 5-inch wg (0 to 1240 Pa)**.



- b. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum **150-psig (1034-kPa)** operating pressure; linear output 4 to 20 mA.
    - c. Water Differential-Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum **150-psig (1034-kPa)** operating pressure and tested to **300-psig (2070-kPa)**; linear output 4 to 20 mA.
    - d. Differential-Pressure Switch (Air or Water): Snap acting, with pilot-duty rating and with suitable scale range and differential.
    - e. Pressure Transmitters: Direct acting for gas, liquid, or steam service; range suitable for system; linear output 4 to 20 mA.
  - 6. Room Sensor Cover Construction: Manufacturer's standard locking covers.
    - a. Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.
    - b. Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
    - c. Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
    - d. Color: As selected from manufacturer's full range.
    - e. Orientation: Vertical **OR** Horizontal, **as directed**.
  - 7. Room sensor accessories include the following:
    - a. Insulating Bases: For sensors located on exterior walls.
    - b. Guards: Locking; heavy-duty, transparent plastic; mounted on separate base **OR** Metal wire, tamperproof **OR** Locking, solid metal, ventilated, **as directed**.
    - c. Adjusting Key: As required for calibration and cover screws.
- H. Pneumatic Sensors
- 1. Pneumatic Transmitters: Vibration and corrosion resistant.
    - a. Space-Temperature Sensors: Linear-output type, **50 to 100 deg F (10 to 38 deg C)** range, with blank locking covers matching room thermostats.
    - b. Room Return-Air Temperature Sensors: Linear-output type with bimetal sensing element and corrosion-proof construction, **50 to 100 deg F (10 to 38 deg C)** range, designed to be mounted in light troffers.
    - c. Duct-Mounted or Immersion-Type Temperature Sensors: Range as required for **3- to 15-psig (21- to 103-kPa)** output signal.
    - d. Temperature Transmitters: Rigid-stem type with bimetal sensing elements unless averaging is required, **3- to 15-psig (21- to 103-kPa)** output signal.
      - 1) Averaging-Element Sensors: Single- or multiple-unit capillary elements.
      - 2) Tamperproof Sensors: Corrosion-resistant construction, suitable for mounting on vibrating surface with exposed capillary protected with temperature-compensated armor or protective tubing.
      - 3) Pipe-Mounted Temperature-Sensing Elements: Rod-and-tube type; with separable wells filled with heat-conductive compound.
      - 4) Outdoors: Provide bulb shield with mounting bracket.
    - e. Space and Duct Humidity Transmitters: One pipe, directly proportional, with minimum sensing span of 20 to 80 percent relative humidity for **3- to 15-psig (21- to 103-kPa)** output signal, corrosion resistant and temperature compensated, and with factory-calibrated adjustment.
      - 1) Space Mounting: With covers to match thermostats.
    - f. Differential-Pressure Transmitters: One pipe, direct acting for gas, liquid, or steam service; pressure sensor and transmitter of linear-output type; with range of **0 to 50 psig (0 to 344 kPa)**, and **3- to 15-psig (21- to 103-kPa)** output signal.
    - g. Differential-Air-Pressure Transmitters: One pipe, direct acting, double bell; unidirectional with suitable range for expected input; and temperature compensated.
      - 1) Accuracy: 5 percent of full range and 2 percent of full scale at midrange.
      - 2) Output Signal: **3 to 15 psig (21 to 103 kPa)**.
  - 2. Digital-to-Pneumatic Transducers: Convert plus or minus 12-V dc pulse-width-modulation outputs, or continuous proportional current or voltage to **0 to 20 psig (0 to 140 kPa)**.
  - 3. Pneumatic Valve/Damper Position Indicator: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.

**I. Status Sensors**

1. Status Inputs for Fans: Differential-pressure switch with pilot-duty rating and with adjustable range of **0- to 5-inch wg (0 to 1240 Pa)**.
2. Status Inputs for Pumps: Differential-pressure switch with pilot-duty rating and with adjustable pressure-differential range of **8 to 60 psig (55 to 414 kPa)**, piped across pump.
3. Status Inputs for Electric Motors: Comply with ISA 50.00.01, current-sensing fixed- or split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.
4. Voltage Transmitter (100- to 600-V ac): Comply with ISA 50.00.01, single-loop, self-powered transmitter, adjustable, with suitable range and 1 percent full-scale accuracy.
5. Power Monitor: 3-phase type with disconnect/shorting switch assembly, listed voltage and current transformers, with pulse kilowatt hour output and 4- to 20-mA kW output, with maximum 2 percent error at 1.0 power factor and 2.5 percent error at 0.5 power factor.
6. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.
7. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
8. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

**J. Gas Detection Equipment**

1. Carbon Monoxide Detectors: Single or multichannel, dual-level detectors using solid-state plug-in sensors with a 3-year minimum life; suitable over a temperature range of **32 to 104 deg F (0 to 40 deg C)**; with 2 factory-calibrated alarm levels at 50 and 100 **OR** 35 and 200, **as directed**, ppm.
2. Carbon Dioxide Sensor and Transmitter: Single detectors using solid-state infrared sensors; suitable over a temperature range of **23 to 130 deg F (minus 5 to plus 55 deg C)** and calibrated for 0 to 2 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.
3. Oxygen Sensor and Transmitter: Single detectors using solid-state zircon cell sensing; suitable over a temperature range of **minus 32 to plus 1100 deg F (0 to 593 deg C)** and calibrated for 0 to 5 percent, with continuous or averaged reading, 4- to 20-mA output; for wall mounting.
4. Occupancy Sensor: Passive infrared, with time delay, daylight sensor lockout, sensitivity control, and 180-degree field of view with vertical sensing adjustment; for flush mounting.

**K. Flow Measuring Stations**

1. Duct Airflow Station: Combination of air straightener and multiport, self-averaging pitot tube station.
  - a. Casing: Galvanized-steel frame.
  - b. Flow Straightener: Aluminum honeycomb, **3/4-inch (20-mm)** parallel cell, **3 inches (75 mm)** deep.
  - c. Sensing Manifold: Copper manifold with bullet-nosed static pressure sensors positioned on equal area basis.

**L. Thermostats**

1. Combination Thermostat and Fan Switches: Line-voltage thermostat with push-button or lever-operated fan switch.
  - a. Label switches "FAN ON-OFF" **OR** "FAN HIGH-LOW-OFF" **OR** "FAN HIGH-MED-LOW-OFF", **as directed**.
  - b. Mount on single electric switch box.
2. Electric, solid-state, microcomputer-based room thermostat with remote sensor.
  - a. Automatic switching from heating to cooling.
  - b. Preferential rate control to minimize overshoot and deviation from set point.
  - c. Set up for four separate temperatures per day.
  - d. Instant override of set point for continuous or timed period from 1 hour to 31 days.
  - e. Short-cycle protection.



- f. Programming based on weekday, Saturday, and Sunday **OR** every day of week, **as directed**.
- g. Selection features include degree F or degree C display, 12- or 24-hour clock, keyboard disable, remote sensor, and fan on-auto.
- h. Battery replacement without program loss.
- i. Thermostat display features include the following:
  - 1) Time of day.
  - 2) Actual room temperature.
  - 3) Programmed temperature.
  - 4) Programmed time.
  - 5) Duration of timed override.
  - 6) Day of week.
  - 7) System mode indications include "heating," "off," "fan auto," and "fan on."
3. Low-Voltage, On-Off Thermostats: NEMA DC 3, 24-V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set-point adjustment, **55 to 85 deg F (13 to 30 deg C)** set-point range, and **2 deg F (1 deg C)** maximum differential.
4. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch or equivalent solid-state type, with heat anticipator; listed for electrical rating; with concealed set-point adjustment, **55 to 85 deg F (13 to 30 deg C)** set-point range, and **2 deg F (1 deg C)** maximum differential.
  - a. Electric Heating Thermostats: Equip with off position on dial wired to break ungrounded conductors.
  - b. Selector Switch: Integral, manual on-off-auto.
5. Remote-Bulb Thermostats: On-off or modulating type, liquid filled to compensate for changes in ambient temperature; with copper capillary and bulb, unless otherwise indicated.
  - a. Bulbs in water lines with separate wells of same material as bulb.
  - b. Bulbs in air ducts with flanges and shields.
  - c. Averaging Elements: Copper tubing with either single- or multiple-unit elements, extended to cover full width of duct or unit; adequately supported.
  - d. Scale settings and differential settings are clearly visible and adjustable from front of instrument.
  - e. On-Off Thermostat: With precision snap switches and with electrical ratings required by application.
  - f. Modulating Thermostats: Construct so complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
6. Fire-Protection Thermostats: Listed and labeled by an NRTL acceptable to authorities having jurisdiction; with fixed or adjustable settings to operate at not less than **75 deg F (24 deg C)** above normal maximum operating temperature, and the following:
  - a. Reset: Manual.  
**OR**  
Reset: Automatic, with control circuit arranged to require manual reset at central control panel; with pilot light and reset switch on panel labeled to indicate operation.
7. Pneumatic Room Thermostats: One **OR** Two **OR** Three, **as directed**, pipe(s), fully proportional with adjustable throttling range and tamperproof locking settings, direct or reverse acting as required. Factory calibrated at **2.5 psig/deg F (17.2 kPa/deg C)**.
  - a. Factory Calibration: **2.5 psig/deg F (17.2 kPa/deg C)**.
  - b. Range: **45 to 85 deg F (7 to 30 deg C)**.
  - c. Sensitivity Adjustment Range: **1 to 4 psig/deg F (7 to 27.6 kPa/deg C)**.
  - d. Dual-Temperature Thermostats: Automatic changeover from normal setting to lower setting for unoccupied cycles, with manual-reset lever to permit return to normal temperatures during unoccupied cycles, with automatic reset to normal during next cycle of operation.
  - e. Limits: Field adjustable, to limit setting cooling set point below **75 deg F (24 deg C)**, and heating set point above **75 deg F (24 deg C)**.
  - f. Room Thermostat Cover Construction: Manufacturer's standard locking covers.
    - 1) Set-Point Adjustment: Concealed **OR** Exposed, **as directed**.

- 2) Set-Point Indication: Concealed **OR** Keyed **OR** Exposed, **as directed**.
  - 3) Thermometer: Concealed **OR** Exposed **OR** Red-reading glass **OR** Spiral bimetal, **as directed**.
  - 4) Color: As selected from manufacturer's full range.
  - 5) Orientation: Vertical **OR** Horizontal, **as directed**.
  - g. Room thermostat accessories include the following:
    - 1) Insulating Bases: For thermostats located on exterior walls.
    - 2) Thermostat Guards: Locking; heavy-duty, transparent plastic; mounted on separate base **OR** Metal wire, tamperproof **OR** Locking, solid metal, ventilated, **as directed**.
    - 3) Adjusting Key: As required for calibration and cover screws.
    - 4) Aspirating Boxes: For flush-mounted aspirating thermostats.
    - 5) Set-Point Adjustment: **1/2-inch- (13-mm-)** diameter, adjustment knob.
  8. Immersion Thermostat: Remote-bulb or bimetal rod-and-tube type, proportioning action with adjustable throttling range and adjustable set point.
  9. Airstream Thermostats: Two-pipe, fully proportional, single-temperature type; with adjustable set point in middle of range, adjustable throttling range, plug-in test fitting or permanent pressure gage, remote bulb, bimetal rod and tube, or averaging element.
  10. Electric, Low-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-, **as directed**, reset switch that trips if temperature sensed across any **12 inches (300 mm)** of bulb length is equal to or below set point.
    - a. Bulb Length: Minimum **20 feet (6 m)**.
    - b. Quantity: One thermostat for every **20 sq. ft. (2 sq. m)** of coil surface.
  11. Electric, High-Limit Duct Thermostat: Snap-acting, single-pole, single-throw, manual- or automatic-, **as directed**, reset switch that trips if temperature sensed across any **12 inches (300 mm)** of bulb length is equal to or above set point.
    - a. Bulb Length: Minimum **20 feet (6 m)**.
    - b. Quantity: One thermostat for every **20 sq. ft. (2 sq. m)** of coil surface.
  12. Heating/Cooling Valve-Top Thermostats: Proportional acting for proportional flow, with molded-rubber diaphragm, remote-bulb liquid-filled element, direct and reverse acting at minimum shutoff pressure of **25 psig (172 kPa)**, and cast housing with position indicator and adjusting knob.
- M. Humidistats
1. Pneumatic Room Humidistats: Wall-mounting, proportioning type with adjustable throttling range, 20 to 90 **OR** 55 to 95 **OR** 25 to 65, **as directed**, percent operating range, and cover matching room thermostat cover.
  2. Duct-Mounting Humidistats: Electric insertion, 2-position type with adjustable, 2 percent throttling range, 20 to 80 percent operating range, and single- or double-pole contacts.
  3. Pneumatic Duct-Mounting Humidistats: Proportioning type with adjustable throttling range, 20 to 90 **OR** 55 to 95 **OR** 25 to 65, **as directed**, percent operating range, in galvanized-steel duct box.
- N. Actuators
1. Electric Motors: Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    - a. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - b. Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
    - c. Nonspring-Return Motors for Valves Larger Than **NPS 2-1/2 (DN 65)**: Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.
    - d. Spring-Return Motors for Valves Larger Than **NPS 2-1/2 (DN 65)**: Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
    - e. Nonspring-Return Motors for Dampers Larger Than **25 Sq. Ft. (2.3 sq. m)**: Size for running torque of **150 in. x lbf (16.9 N x m)** and breakaway torque of **300 in. x lbf (33.9 N x m)**.

- f. Spring-Return Motors for Dampers Larger Than **25 Sq. Ft. (2.3 sq. m)**: Size for running and breakaway torque of **150 in. x lbf (16.9 N x m)**.
  2. Electronic Actuators: Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
    - a. Valves: Size for torque required for valve close off at maximum pump differential pressure.
    - b. Dampers: Size for running torque calculated as follows:
      - 1) Parallel-Blade Damper with Edge Seals: **7 inch-lb/sq. ft. (86.8 kg-cm/sq. m)** of damper.
      - 2) Opposed-Blade Damper with Edge Seals: **5 inch-lb/sq. ft. (62 kg-cm/sq. m)** of damper.
      - 3) Parallel-Blade Damper without Edge Seals: **4 inch-lb/sq. ft. (49.6 kg-cm/sq. m)** of damper.
      - 4) Opposed-Blade Damper without Edge Seals: **3 inch-lb/sq. ft. (37.2 kg-cm/sq. m)** of damper.
      - 5) Dampers with **2- to 3-Inch wg (500 to 750 Pa)** of Pressure Drop or Face Velocities of **1000 to 2500 fpm (5 to 13 m/s)**: Increase running torque by 1.5.
      - 6) Dampers with **3- to 4-Inch wg (750 to 1000 Pa)** of Pressure Drop or Face Velocities of **2500 to 3000 fpm (13 to 15 m/s)**: Increase running torque by 2.0.
    - c. Coupling: V-bolt and V-shaped, toothed cradle.
    - d. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
    - e. Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on nonspring-return actuators.
    - f. Power Requirements (Two-Position Spring Return): **24 OR 120 OR 230, as directed**, -V ac.
    - g. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
    - h. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
    - i. Temperature Rating: **Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) OR 40 to 104 deg F (5 to 40 deg C), as directed.**
    - j. Temperature Rating (Smoke Dampers): **Minus 22 to plus 250 deg F (Minus 30 to plus 121 deg C).**
    - k. Run Time: 12 seconds open, 5 seconds closed **OR 30 seconds OR 60 seconds OR 120 seconds, as directed.**
  3. Pneumatic Valve Operators: Rolling-diaphragm, spring-loaded, piston type with spring range as required and start-point adjustment and positioning relay, **as directed**. Operator shall maintain full shutoff at maximum pump differential pressure.
  4. Pneumatic Damper Operators: Rolling-diaphragm, piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Where actuators operate in sequence, provide pilot positioners.
    - a. Pilot Positioners: With the following characteristics:
      - 1) Start Point: Adjustable from **2 to 12 psig (14 to 83 kPa)**.
      - 2) Operating Span: Adjustable from **5 to 13 psig (35 to 90 kPa)**.
      - 3) Linearity: Plus or minus 10 percent of output signal span.
      - 4) Hysteresis: 3 percent of span.
      - 5) Response: **0.25-psig (1723-Pa)** input change.
      - 6) Maximum Pilot Signal Pressure: **20 psig (140 kPa)**.
      - 7) Maximum Control Air-Supply Pressure: **60 psig (410 kPa)**.
    - b. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of **50 to 140 deg F (10 to 60 deg C)** unless located in return-air plenums, **as directed**.
    - c. Inlet-Vane Operators: High pressure, with pilot positioners.
- O. Control Valves
  1. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
  2. Hydronic system globe valves shall have the following characteristics:



- a. **NPS 2 (DN 50)** and Smaller: Class 125 **OR** 250, **as directed**, bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
  - b. **NPS 2-1/2 (DN 65)** and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
  - c. Internal Construction: Replaceable plugs and stainless-steel or brass seats.
    - 1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom.
    - 2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom.
  - d. Sizing: **3-psig (21-kPa)** **OR** **5-psig (35-kPa)**, **as directed**, maximum pressure drop at design flow rate or the following:
    - 1) Two Position: Line size.
    - 2) Two-Way Modulating: Either the value specified above or twice the load pressure drop, whichever is more.
    - 3) Three-Way Modulating: Twice the load pressure drop, but not more than value specified above.
  - e. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
  - f. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of total system (pump) head for two-way valves and 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
3. Steam system globe valves shall have the following characteristics:
- a. **NPS 2 (DN 50)** and Smaller: Class 125 bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure.
  - b. **NPS 2-1/2 (DN 65)** and Larger: Class 125 iron body, bronze trim, rising stem, plug-type disc, flanged ends, and renewable seat and disc.
  - c. Internal Construction: Replaceable plugs and stainless-steel seats.
    - 1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
    - 2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
  - d. Sizing: For pressure drop based on the following services:
    - 1) Two Position: 20 percent of inlet pressure.
    - 2) Modulating **15-psig (103-kPa)** Steam: 80 percent of inlet steam pressure.
    - 3) Modulating **16- to 50-psig (110- to 350-kPa)** Steam: 50 percent of inlet steam pressure.
    - 4) Modulating More Than **50-psig (350-kPa)** Steam: As indicated.
  - e. Flow Characteristics: Modified linear characteristics.
  - f. Close-Off (Differential) Pressure Rating: Combination of actuator and trim shall provide minimum close-off pressure rating of 150 percent of operating (inlet) pressure.
4. Butterfly Valves: **200-psig (1380-kPa)**, **150-psig (1034-kPa)** maximum pressure differential, ASTM A 126 cast-iron or ASTM A 536 ductile-iron body and bonnet, extended neck, stainless-steel stem, field-replaceable EPDM or Buna N sleeve and stem seals.
- a. Body Style: Wafer **OR** Lug **OR** Grooved, **as directed**.
  - b. Disc Type: Nickel-plated ductile iron **OR** Aluminum bronze **OR** Elastomer-coated ductile iron **OR** Epoxy-coated ductile iron, **as directed**.
  - c. Sizing: **1-psig (7-kPa)** maximum pressure drop at design flow rate.
5. Terminal Unit Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
- a. Rating: Class 125 for service at **125 psig (860 kPa)** and **250 deg F (121 deg C)** operating conditions.
  - b. Sizing: **3-psig (21-kPa)** maximum pressure drop at design flow rate, to close against pump shutoff head.



- c. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
  6. Self-Contained Control Valves: Bronze body, bronze trim, two or three ports as indicated, replaceable plugs and seats, and union and threaded ends.
    - a. Rating: Class 125 for service at **125 psig (860 kPa)** and **250 deg F (121 deg C)** operating conditions.
    - b. Thermostatic Operator: Wax **OR** Liquid, **as directed**,-filled integral **OR** remote, **as directed**, sensor with integral **OR** remote, **as directed**, adjustable dial.
- P. Dampers
  1. Dampers: AMCA-rated, parallel **OR** opposed, **as directed**,-blade design; **0.108-inch- (2.8-mm-)** minimum thick, galvanized-steel or **0.125-inch- (3.2-mm-)** minimum thick, extruded-aluminum frames with holes for duct mounting; damper blades shall not be less than **0.064-inch- (1.6-mm-)** thick galvanized steel with maximum blade width of **8 inches (200 mm)** and length of **48 inches (1220 mm)**.
    - a. Secure blades to **1/2-inch- (13-mm-)** diameter, zinc-plated axles using zinc-plated hardware, with oil-impregnated sintered bronze **OR** nylon, **as directed**, blade bearings, blade-linkage hardware of zinc-plated steel and brass, ends sealed against spring-stainless-steel blade bearings, and thrust bearings at each end of every blade.
    - b. Operating Temperature Range: From **minus 40 to plus 200 deg F (minus 40 to plus 93 deg C)**.
    - c. Edge Seals, Standard Pressure Applications: Closed-cell neoprene.  
**OR**  
Edge Seals, Low-Leakage Applications: Use inflatable blade edging or replaceable rubber blade seals and spring-loaded stainless-steel side seals, rated for leakage at less than **10 cfm per sq. ft. (50 L/s per sq. m)** of damper area, at differential pressure of **4-inch wg (1000 Pa)** when damper is held by torque of **50 in. x lbf (5.6 N x m)**; when tested according to AMCA 500D.
- Q. Air Supply
  1. Control and Instrumentation Tubing: Copper tubing complying with **ASTM B 88, Type K (ASTM B 88M, Type A)** or ASTM B 280 Type ACR.
    - a. Fittings: Cast-bronze solder fittings complying with ASME B16.18; or wrought-copper solder fittings complying with ASME B16.22, except forged-brass compression-type fittings at connections to equipment.
    - b. Joining Method: Soldered or brazed.  
**OR**  
Control and Instrumentation Tubing: ASTM D 2737 Type FR plenum-rated polyethylene, flame-retardant, nonmetallic tubing rated for **30 psig (207 kPa)** and ambient temperature range of **10 to 150 deg F (minus 13 to plus 65 deg C)** with flame-retardant harness for multiple tubing.
    - c. Fittings: Compression or push-on polyethylene fittings.
  2. Tank: ASME storage tank with drain test cock, automatic moisture removal trap, tank relief valve, and rubber-cork vibration isolation mounting pads.
  3. Duplex Air Compressor: Capacity to supply compressed air to temperature-control system.
    - a. Pressure control with adjustable electric contacts, set to start and stop both compressors at different pressures.
    - b. Electrical alternation set with motor starters and disconnect to operate compressors alternately or on time schedule.
  4. Simplex Air Compressor: Tank-mounting compressor with capacity to supply compressed air to temperature-control system, with starter and disconnect.
    - a. Pressure control with adjustable electric contacts, set to start and stop compressor.
  5. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
  6. Size compressor and tank to operate compressor not more than **20 OR 30, as directed**, minutes during a 60-minute period.
  7. Compressor Accessories: Low-resistance intake-air filter, and belt guards.



8. System Accessories: Air filter rated for 97 percent efficiency at rated airflow, and combination filter/pressure-reducing station or separate filter and pressure-reducing station.
9. Refrigerated Air Dryer: Self-contained, refrigerated air dryer complete with heat exchangers, moisture separator, internal wiring and piping, and with manual bypass valve.
  - a. Heat Exchangers: Air-to-refrigerant coils with centrifugal-type moisture separator and automatic trap assembly.
  - b. Refrigeration Unit: Hermetically sealed, operating to maintain dew point of **13 deg F (minus 11 deg C)** at **20 psig (140 kPa)**, housed in steel cabinet with access door and panel.
  - c. Accessories: Air-inlet temperature gage, air-inlet pressure gage, on-off switch, high-temperature light, power-on light, refrigerant gage on back, air-outlet temperature gage, air-outlet pressure gage, and with contacts for remote indication of power status and high-temperature alarm.
10. Desiccant Dryer: Obtains dew point in pneumatic air piping between compressor and tank at least **15 deg F (minus 9 deg C)** below inlet-air dew point at design conditions.
11. Pressure Gages: Black letters on white background, **2-1/2 inches (64 mm)** in diameter, flush or surface mounting, with front calibration screw to match sensor, and having a graduated scale in **psig (kPa)**.
12. Instrument Pressure Gages: Black letters on white background, **1-1/2 inches (38 mm)** in diameter, stem mounted, with suitable dial range.
13. Diaphragm Control and Instrument Valves: **1/4-inch (6-mm)** forged-brass body with reinforced polytetrafluoroethylene diaphragm, stainless-steel spring, and color-coded phenolic handle.
14. Gage Cocks: Tee or level handle, bronze, rated for **125 psig (860 kPa)**.
15. Relays: For summing, reversing, and amplifying highest or lowest pressure selection; with adjustable I/O ratio.
16. Switches: With indicating plates and accessible adjustment; calibrated and marked.
17. Pressure Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve.
18. Particle Filters: Zinc or aluminum castings with 97 percent filtration efficiency at rated airflow, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.
19. Combination Filter/Regulators: Zinc or aluminum castings with elastomeric diaphragm, balanced construction to automatically prevent pressure buildup, and producing flat reduced-pressure curve; with threaded pipe connections, quick-disconnect service devices, and aluminum or plastic bowl with metal guard and manual drain cock.
20. Airborne Oil Filter: Filtration efficiency of 99.9 percent for airborne lubricating oil particles of 0.025 micron or larger.
21. Pressure Relief Valves: ASME rated and labeled.
  - a. High Pressure: Size for installed capacity.
  - b. Low Pressure: Size for installed capacity of pressure regulators and set at 20 percent above low pressure.
22. Pressure-Reducing Stations: Two parallel pressure regulators.

R. Control Cable

1. Electronic and fiber-optic cables for control wiring are specified in Division 27 Section "Communications Horizontal Cabling".

### 1.3 EXECUTION

A. Installation

1. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
2. Connect and configure equipment and software to achieve sequence of operation specified.

3. Mount compressor and tank unit on elastomeric mounts **OR** spring isolators with **1-inch (25 mm)** static deflection **OR** restrained spring isolators with **1-inch (25-mm)** static deflection, **as directed**. Vibration isolators are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Isolate air supply with wire-braid-reinforced rubber hose. Secure and anchor according to manufacturer's written instructions and seismic-control requirements.
    - a. Pipe manual and automatic drains to nearest floor drain.
    - b. Supply instrument air from compressor units through filter, pressure-reducing valve, and pressure relief valve, with pressure gages and shutoff and bypass valves.
  4. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices **48 inches (1220 mm) OR 60 inches (1530 mm)**, **as directed**, above the floor.
    - a. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
  5. Install guards on thermostats in the following locations:
    - a. Entrances.
    - b. Public areas.
    - c. Where indicated.
  6. Install automatic dampers according to Division 23 Section "Air Duct Accessories".
  7. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
  8. Install labels and nameplates to identify control components according to Division 23 Section "Identification For Hvac Piping And Equipment".
  9. Install hydronic instrument wells, valves, and other accessories according to Division 23 Section "Hydronic Piping".
  10. Install steam and condensate instrument wells, valves, and other accessories according to Division 23 Section "Steam And Condensate Heating Piping".
  11. Install refrigerant instrument wells, valves, and other accessories according to Division 23 Section "Refrigerant Piping".
  12. Install duct volume-control dampers according to Division 21 specifying air ducts.
  13. Install electronic and fiber-optic cables according to Division 27 Section "Communications Horizontal Cabling".
- B. Pneumatic Piping Installation
1. Install piping in mechanical equipment rooms inside mechanical equipment enclosures, in pipe chases, or suspended ceilings with easy access.
    - a. Install copper tubing with maximum unsupported length of **36 inches (915 mm)**, for tubing exposed to view.
    - b. Install polyethylene tubing in metallic raceways or electrical metallic tubing. Electrical metallic tubing materials and installation requirements are specified in Division 26 Section "Underfloor Raceways For Electrical Systems".
  2. Install terminal single-line connections, less than **18 inches (460 mm)** in length, with copper or polyethylene tubing run inside flexible steel protection.
  3. In concealed locations such as pipe chases and suspended ceilings with easy access, install copper **OR** polyethylene bundled and sheathed **OR** polyethylene tubing in electrical metallic, **as directed**, tubing. Electrical metallic tubing materials and installation requirements are specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
  4. In concrete slabs, furred walls, or ceilings with no access, install copper or polyethylene tubing in electrical metallic tubing or vinyl-jacketed polyethylene tubing.
    - a. Protect embedded-copper and vinyl-jacketed polyethylene tubing with electrical metallic tubing extending **6 inches (150 mm)** above finished slab and **6 inches (150 mm)** into slab. Pressure test tubing before and after pour for leak and pinch.
    - b. Install polyethylene tubing in electrical metallic tubing extending **6 inches (150 mm)** above floor line; pull tubing into electrical metallic tubing after pour.
  5. Install tubing with sufficient slack and flexible connections to allow for vibration of piping and equipment.
  6. Purge tubing with dry, oil-free compressed air before connecting control instruments.



- a. Bridge cabinets and doors with flexible connections fastened along hinge side; protect against abrasion. Tie and support tubing.
  7. Number-code or color-code control air piping for future identification and service of control system, except local individual room control tubing.
  8. Pressure Gages or Test Plugs: Install on branch lines at each receiver controller and on signal lines at each transmitter, except individual room controllers.
- C. Electrical Wiring And Connection Installation
  1. Install raceways, boxes, and cabinets according to Division 26 Section "Raceway And Boxes For Electrical Systems".
  2. Install building wire and cable according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
  3. Install signal and communication cable according to Division 27 Section "Communications Horizontal Cabling".
    - a. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
    - b. Install exposed cable in raceway.
    - c. Install concealed cable in raceway.
    - d. Bundle and harness multiconductor instrument cable in place of single cables where several cables follow a common path.
    - e. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.
    - f. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
    - g. Install wire and cable with sufficient slack and flexible connections to allow for vibration of piping and equipment.
  4. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
  5. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.
- D. Field Quality Control
  1. Perform the following field tests and inspections and prepare test reports:
    - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
    - b. Test and adjust controls and safeties.
    - c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
    - d. Pressure test control air piping at **30 psig (207 kPa)** or 1.5 times the operating pressure for 24 hours, with maximum **5-psig (35-kPa)** loss.
    - e. Pressure test high-pressure control air piping at **150 psig (1034 kPa)** and low-pressure control air piping at **30 psig (207 kPa)** for 2 hours, with maximum **1-psig (7-kPa)** loss.
    - f. Test calibration of pneumatic **OR** electronic, **as directed**, controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
    - g. Test each point through its full operating range to verify that safety and operating control set points are as required.
    - h. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
    - i. Test each system for compliance with sequence of operation.
    - j. Test software and hardware interlocks.
  2. DDC Verification:
    - a. Verify that instruments are installed before calibration, testing, and loop or leak checks.
    - b. Check instruments for proper location and accessibility.
    - c. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.

- d. Check instrument tubing for proper fittings, slope, material, and support.
  - e. Check installation of air supply for each instrument.
  - f. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
  - g. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
  - h. Check temperature instruments and material and length of sensing elements.
  - i. Check control valves. Verify that they are in correct direction.
  - j. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
  - k. Check DDC system as follows:
    - 1) Verify that DDC controller power supply is from emergency power supply, if applicable.
    - 2) Verify that wires at control panels are tagged with their service designation and approved tagging system.
    - 3) Verify that spare I/O capacity has been provided.
    - 4) Verify that DDC controllers are protected from power supply surges.
  - 3. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.
- E. Adjusting
- 1. Calibrating and Adjusting:
    - a. Calibrate instruments.
    - b. Make three-point calibration test for both linearity and accuracy for each analog instrument.
    - c. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
    - d. Control System Inputs and Outputs:
      - 1) Check analog inputs at 0, 50, and 100 percent of span.
      - 2) Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
      - 3) Check digital inputs using jumper wire.
      - 4) Check digital outputs using ohmmeter to test for contact making or breaking.
      - 5) Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.
    - e. Flow:
      - 1) Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
      - 2) Manually operate flow switches to verify that they make or break contact.
    - f. Pressure:
      - 1) Calibrate pressure transmitters at 0, 50, and 100 percent of span.
      - 2) Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
    - g. Temperature:
      - 1) Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
      - 2) Calibrate temperature switches to make or break contacts.
    - h. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
    - i. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
    - j. Provide diagnostic and test instruments for calibration and adjustment of system.
    - k. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.
  - 2. Adjust initial temperature and humidity set points.



3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose.

F. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls.

END OF SECTION 23 09 00 00

NOT FOR BID

## SECTION 23 09 23 53 - ENCLOSED CONTROLLERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for enclosed controllers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes the following enclosed controllers rated 600 V and less:
  - a. Full-voltage manual.
  - b. Full-voltage magnetic.
  - c. Reduced-voltage magnetic.
  - d. Reduced-voltage solid state.
  - e. Multispeed.

#### C. Definitions

1. CPT: Control power transformer.
2. MCCB: Molded-case circuit breaker.
3. MCP: Motor circuit protector.
4. N.C.: Normally closed.
5. N.O.: Normally open.
6. OCPD: Overcurrent protective device.
7. SCR: Silicon-controlled rectifier.

#### D. Performance Requirements

1. Seismic Performance: Enclosed controllers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
2. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
  - a. Show tabulations of the following:
    - 1) Each installed unit's type and details.
    - 2) Factory-installed devices.
    - 3) Nameplate legends.
    - 4) Short-circuit current rating of integrated unit.
    - 5) Listed and labeled for integrated short-circuit current (withstand) rating of OCPDs in combination controllers by an NRTL acceptable to authorities having jurisdiction.
    - 6) Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.
  - b. Wiring Diagrams: For power, signal, and control wiring.
3. Qualification Data: For qualified testing agency.
4. Seismic Qualification Certificates: For enclosed controllers, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.



- b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
    - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
  5. Field quality-control reports.
  6. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. Include the following:
    - a. Routine maintenance requirements for enclosed controllers and installed components.
    - b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
    - c. Manufacturer's written instructions for setting field-adjustable overload relays.
    - d. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.
  7. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
  8. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.
- F. Quality Assurance
  1. Testing Agency Qualifications: Member company of NETA or an NRTL **OR** one who meets the requirements necessary for certification, **as directed**.
    - a. Testing Agency's Field Supervisor: Currently certified by NETA **OR** one who meets the requirements necessary for certification, **as directed**, to supervise on-site testing.
  2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  3. Comply with NFPA 70.
  4. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
- G. Delivery, Storage, And Handling
  1. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
  2. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install temporary electric heating, with at least 250 W per controller **OR** connect factory-installed space heaters to temporary electrical service, **as directed**.
- H. Project Conditions
  1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    - a. Ambient Temperature: Not less than **minus 22 deg F (minus 30 deg C)** and not exceeding **104 deg F (40 deg C)**.
    - b. Altitude: Not exceeding **6600 feet (2010 m)**.
  2. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
    - a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical systems.
    - b. Indicate method of providing temporary utilities.
    - c. Do not proceed with interruption of electrical systems without the Owner's written permission.
    - d. Comply with NFPA 70E.

- I. Coordination
  1. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
  2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 3.
  3. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

## 1.2 PRODUCTS

### A. Full-Voltage Controllers

1. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
2. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
  - a. Configuration: Nonreversing **OR** Reversing **OR** Two speed, **as directed**.
  - b. Flush **OR** Surface, **as directed**, mounting.
  - c. Red **OR** Green, **as directed**, pilot light.
  - d. Additional Nameplates: FORWARD and REVERSE for reversing switches **OR** HIGH and LOW for two-speed switches, **as directed**.
3. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
  - a. Configuration: Nonreversing **OR** Two speed, **as directed**.
  - b. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button; bimetallic type **OR** melting alloy type, **as directed**.
  - c. Flush **OR** Surface, **as directed**, mounting.
  - d. Red **OR** Green, **as directed**, pilot light.
  - e. Additional Nameplates: HIGH and LOW for two-speed controllers.
4. Integral Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
  - a. Configuration: Nonreversing **OR** Reversing **OR** Two speed, **as directed**.
  - b. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters and sensors in each phase, matched to nameplate full-load current of actual protected motor and having appropriate adjustment for duty cycle; external reset push button; bimetallic type **OR** melting alloy type, **as directed**.
  - c. Flush **OR** Surface, **as directed**, mounting.
  - d. Red **OR** Green, **as directed**, pilot light.
  - e. Additional Nameplates: FORWARD and REVERSE for reversing controllers **OR** HIGH and LOW for two-speed controllers, **as directed**.
  - f. N.O. **OR** N.C., **as directed**, auxiliary contact.
5. Magnetic Controllers: Full voltage, across the line, electrically held.
  - a. Configuration: Nonreversing **OR** Reversing, **as directed**.
  - b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
    - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
  - c. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
  - d. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
    - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
  - e. Melting Alloy Overload Relays:



- 1) Inverse-time-current characteristic.
- 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
- 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
- f. Bimetallic Overload Relays:
  - 1) Inverse-time-current characteristic.
  - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
  - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - 4) Ambient compensated.
  - 5) Automatic resetting.
- g. Solid-State Overload Relay:
  - 1) Switch or dial selectable for motor running overload protection.
  - 2) Sensors in each phase.
  - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
  - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
  - 5) Analog communication module.
- h. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
- i. External overload reset push button.
6. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
  - a. Fusible Disconnecting Means:
    - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
  - b. Nonfusible Disconnecting Means:
    - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
  - c. MCP Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
    - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
    - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
  - d. MCCB Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.

- 5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.
- B. Reduced-Voltage Magnetic Controllers
1. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed-transition; adjustable time delay on transition.
  2. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
    - a. Configuration:
      - 1) Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
      - 2) Part-Winding Controller: Separate START and RUN contactors, field-selectable for 1/2- or 2/3-winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
      - 3) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
    - b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
      - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    - c. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
    - d. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
      - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
    - e. Melting Alloy Overload Relays:
      - 1) Inverse-time-current characteristic.
      - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    - f. Bimetallic Overload Relays:
      - 1) Inverse-time-current characteristic.
      - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
      - 4) Ambient compensated.
      - 5) Automatic resetting.
    - g. Solid-State Overload Relay:
      - 1) Switch or dial selectable for motor running overload protection.
      - 2) Sensors in each phase.
      - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
      - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
      - 5) Analog communication module.
    - h. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
    - i. External overload reset push button.
  3. Combination Reduced-Voltage Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
    - a. Fusible Disconnecting Means:
      - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.
      - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

- 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
  - b. Nonfusible Disconnecting Means:
    - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
  - c. MCP Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
    - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
    - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
  - d. MCCB Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
    - 5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.
- C. Reduced-Voltage Solid-State Controllers
1. General Requirements for Reduced-Voltage Solid-State Controllers: Comply with UL 508.
  2. Reduced-Voltage Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium induction motors.
    - a. Configuration: Standard duty **OR** Severe duty, **as directed**; nonreversible **OR** reversible, **as directed**.
    - b. Starting Mode: Voltage ramping **OR** Current limit **OR** Torque control **OR** Torque control with voltage boost, **as directed**; field selectable, **as directed**.
    - c. Stopping Mode: Coast to stop **OR** Adjustable torque deceleration **OR** Adjustable braking, **as directed**; field selectable, **as directed**.
    - d. Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
    - e. Shorting and Input Isolation, **as directed**, Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors, **as directed**.
    - f. Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
    - g. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
      - 1) CPT Spare Capacity: 100 **OR** 200, **as directed**, VA.

- h. Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
- i. SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with **OR** without, **as directed**, external feedback from the motor or driven equipment.
- j. Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
  - 1) Adjusting motor full-load amperes, as a percentage of the controller's rating.
  - 2) Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
  - 3) Adjusting linear acceleration and deceleration ramps, in seconds.
  - 4) Initial torque, as a percentage of the nominal motor torque.
  - 5) Adjusting torque limit, as a percentage of the nominal motor torque.
  - 6) Adjusting maximum start time, in seconds.
  - 7) Adjusting voltage boost, as a percentage of the nominal supply voltage.
  - 8) Selecting stopping mode, and adjusting parameters.
  - 9) Selecting motor thermal overload protection class between 5 and 30.
  - 10) Activating and de-activating protection modes.
  - 11) Selecting or activating communication modes.
- k. Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
  - 1) Controller Condition: Ready, starting, running, stopping.
  - 2) Motor Condition: Amperes, voltage, power factor, power, and thermal state.
  - 3) Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.
- l. Controller Diagnostics and Protection:
  - 1) Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
  - 2) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
  - 3) Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component or when the motor is stopped.

**OR**

Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.
- m. Remote Output Features:
  - 1) All outputs prewired to terminal blocks.
  - 2) Form C status contacts that change state when controller is running.
  - 3) Form C alarm contacts that change state when a fault condition occurs.
- n. Optional Features:
  - 1) Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc **OR** 4 to 20-mA dc, **as directed**.
  - 2) Additional field-assignable Form C contacts, as indicated, for alarm outputs.
  - 3) Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  - 4) Full-voltage bypass contactor operating automatically **OR** manually, with NORMAL/BYPASS selector switch, **as directed**. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.
  - 5) Melting Alloy Overload Relays:
    - a) Inverse-time-current characteristic.
    - b) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.

- c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - 6) Bimetallic Overload Relays:
    - a) Inverse-time-current characteristic.
    - b) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
    - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    - d) Ambient compensated.
    - e) Automatic resetting.
  - 7) Solid-State Overload Relay:
    - a) Switch or dial selectable for motor running overload protection.
    - b) Sensors in each phase.
    - c) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    - d) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    - e) Analog communication module.
  - 8) N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
  - 9) External overload reset push button.
- 3. Combination Reduced-Voltage Solid-State Controller: Factory-assembled combination of reduced-voltage solid-state controller, OCPD, and disconnecting means.
  - a. Fusible Disconnecting Means:
    - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class L **OR** indicated, **as directed**, fuses.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
  - b. MCP Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
    - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
    - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
  - c. MCCB Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
    - 5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.
  - d. Molded-Case Switch Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

- 3) Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
  - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when molded-case switch has tripped.
- D. Multispeed Magnetic Controllers
1. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
  2. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held.
    - a. Configuration: Nonreversing **OR** Reversing, **as directed**; consequent pole **OR** two winding, **as directed**.
    - b. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
      - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    - c. Power Contacts: Totally enclosed, double break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
    - d. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
      - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
    - e. Compelling relays shall ensure that motor will start only at low speed.
    - f. Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
    - g. Decelerating timer relays shall ensure automatically timed deceleration through each speed.
    - h. Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.
    - i. Melting Alloy Overload Relays:
      - 1) Inverse-time-current characteristic.
      - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    - j. Bimetallic Overload Relays:
      - 1) Inverse-time-current characteristic.
      - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
      - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
      - 4) Ambient compensated.
      - 5) Automatic resetting.
    - k. Solid-State Overload Relay:
      - 1) Switch or dial selectable for motor running overload protection.
      - 2) Sensors in each phase.
      - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
      - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
      - 5) Analog communication module.
    - l. N.C. **OR** N.O., **as directed**, isolated overload alarm contact.
    - m. External overload reset push button.
  3. Combination Multispeed Magnetic Controller: Factory-assembled combination of reduced-voltage magnetic controller, OCPD, and disconnecting means.
    - a. Fusible Disconnecting Means:
      - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class R **OR** indicated, **as directed**, fuses.



- 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
- 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- b. Nonfusible Disconnecting Means:
  - 1) NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
  - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
  - 3) Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
- c. MCP Disconnecting Means:
  - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
  - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
  - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
  - 4) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCP has tripped.
  - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
- d. MCCB Disconnecting Means:
  - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
  - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
  - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
  - 5) N.C. **OR** N.O., **as directed**, alarm contact that operates only when MCCB has tripped.

#### E. Enclosures

- 1. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
  - a. Dry and Clean Indoor Locations: Type 1.
  - b. Outdoor Locations: Type 3R **OR** Type 4X, **as directed**.
  - c. Kitchen **OR** Wash-Down, **as directed**, Areas: Type 4X, stainless steel.
  - d. Other Wet or Damp Indoor Locations: Type 4.
  - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
  - f. Hazardous Areas Indicated on Drawings: Type 7 **OR** Type 9, **as directed**.

#### F. Accessories

- 1. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
  - a. Push Buttons, Pilot Lights, and Selector Switches: Heavy **OR** Standard, **as directed**, -duty, oiltight, **as directed**, type.
    - 1) Push Buttons: Covered **OR** Lockable **OR** Recessed **OR** Shielded **OR** Shrouded **OR** Unguarded, **as directed**, types; maintained **OR** momentary, **as directed**, as indicated.
    - 2) Pilot Lights: Incandescent **OR** LED **OR** Neon **OR** Resistor **OR** Transformer, **as directed**, types; colors as indicated; push to test, **as directed**.
    - 3) Selector Switches: Rotary type.
  - b. Elapsed Time Meters: Heavy duty with digital readout in hours; nonresettable **OR** resettable, **as directed**.



- c. Meters: Panel type, **2-1/2-inch (64-mm)** minimum size with 90- or 120-degree scale and plus or minus two percent accuracy. Where indicated, provide selector switches with an off position.
2. N.C. **OR** N.O. **OR** Reversible N.C./N.O., **as directed**, auxiliary contact(s).
3. Control Relays: Auxiliary and adjustable pneumatic **OR** solid-state, **as directed**, time-delay relays.
4. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
5. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4 **OR** Type 4X **OR** Type 7 **OR** Type 9, **as directed**, enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
6. Space heaters, with N.C. auxiliary contacts, to mitigate condensation in Type 3R **OR** Type 4X **OR** Type 12, **as directed**, enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
7. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
8. Cover gaskets for Type 1 enclosures.
9. Terminals for connecting power factor correction capacitors to the line **OR** load, **as directed**, side of overload relays.
10. Spare control wiring terminal blocks, quantity as indicated; unwired **OR** wired, **as directed**.

### 1.3 EXECUTION

#### A. Examination

1. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
2. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Installation

1. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers And Supports For Electrical Systems".
2. Floor-Mounted Controllers: Install enclosed controllers on **4-inch (100-mm)** nominal-thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in each fusible-switch enclosed controller.
6. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses".
7. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.



8. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
9. Install power factor correction capacitors. Connect to the line **OR** load, **as directed**, side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
10. Comply with NECA 1.

C. Identification

1. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
  - a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
  - b. Label each enclosure with engraved nameplate.
  - c. Label each enclosure-mounted control and pilot device.

D. Control Wiring Installation

1. Install wiring between enclosed controllers and remote devices and facility's central control system, **as directed**. Comply with requirements in Division 26 Section "Control-voltage Electrical Power Cables".
2. Bundle, train, and support wiring in enclosures.
3. Connect selector switches and other automatic-control selection devices where applicable.
  - a. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
  - b. Connect selector switches with enclosed-controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

E. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Perform tests and inspections.
3. Acceptance Testing Preparation:
  - a. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
  - b. Test continuity of each circuit.
4. Tests and Inspections:
  - a. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment, **as directed**.
  - b. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
  - c. Test continuity of each circuit.
  - d. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify the Owner before starting the motor(s).
  - e. Test each motor for proper phase rotation.
  - f. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - g. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
  - h. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
    - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multi-pole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
    - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multi-pole enclosed controller 11 months after date of Final Completion.

- 3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - i. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
  5. Enclosed controllers will be considered defective if they do not pass tests and inspections.
  6. Prepare test and inspection reports including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- F. Adjusting
1. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
  2. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
  3. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify the Owner before increasing settings.
  4. Set the taps on reduced-voltage autotransformer controllers at 50 **OR** 65 **OR** 80, **as directed**, percent.
  5. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage solid-state controllers.
  6. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study", **as directed**.
- G. Protection
1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
  2. Replace controllers whose interiors have been exposed to water or other liquids prior to Final Completion.
- H. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage solid-state controllers, **as directed**.

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Task	Specification	Specification Description
23 09 23 53	23 09 00 00	HVAC Instrumentation And Controls
23 09 43 00	23 09 00 00	HVAC Instrumentation And Controls

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## SECTION 23 11 23 00 - RELIEF WELLS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for relief wells. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Shop Drawings: Submit shop drawings.
2. Statements
  - a. Before installation, all well screen shall be approved.
  - b. The filter pack material and its gradation shall be approved before it is placed.
  - c. Submit the cement grout mixture proportion to be used in plugging abandoned wells.
3. Reports: Submit sampling and testing reports for each relief well, logs of the borings, well screen and riser pipe, backfill material, and pump tests. Register each well with the state as required by the state in which the well is installed.

- #### C. Regulatory Requirements:
- The state statutory and regulatory requirements form a part of this specification.

### 1.2 PRODUCTS

- #### A. Well Screen:
- The Contractor may, at its option, furnish and install well screen of any of the alternate types specified. The clear inside diameter of the screen shall be as directed by the Owner. Screen openings shall be uniform in size and pattern, and shall be spaced approximately equally around the circumference of the pipe.

1. PVC Pipe Screen: Pipe, fittings, and screen shall be of the size and types specified. Pipe, fittings, and screen shall conform to ASTM D 1784, ASTM D 1785, ASTM D 2466, or ASTM D 2467. All joints in the PVC pipe shall include couplings and shall be glued with a solvent cement conforming to ASTM D 2564. The PVC pipe strength properties shall be equivalent to PVC 1120 Schedule 40 **OR 80, as directed**, unthreaded plastic pipe.

- a. Couplings: Couplings shall be bonded socket **OR** threaded, **OR** certilock, **as directed**, type. Fittings shall be produced of the same material and equal quality as specified for plastic pipe screen. Socket type fitting connections of pipe sections shall be bonded with solvent cement. The determination of the proportions and preparation of adhesives, the method of application, and the procedure used for making and curing the connections shall be the responsibility of the Contractor. The system for making joints at the relief well site shall provide a curing period adequate to develop the ultimate strength of the solvent cement. Self-tapping screws or other devices for holding pipe in the couplings during the setting period may be utilized as long as the screws do not penetrate the inside of the pipe. In no case shall a newly-made joint in the casing be stressed, lowered into the relief well, or be submerged in water prior to complete curing of the solvent cement adhesive.

- b. Perforations: The PVC well screen shall be mill slot **OR** continuous wire wrapped rod base **OR** continuous wire wrapped rod base on perforated pipe **OR** continuous wire wrapped on perforated pipe screen **OR** similar to that manufactured by Johnson Well Equipment, Inc., Pensacola, FL, telephone (904) 453-3131, **as directed**. All well screen shall have smooth, sharp-edged openings free of burns, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.





2. **Fiberglass Pipe Screen:** Fiberglass pipe screen and fittings shall be manufactured from thermosetting epoxy resins and glass fiber by either a centrifugal casting process or by a filament winding process. Glass fiber used shall be continuous filament, electrical glass with a finish compatible with epoxy resins. Each glass fiber or filament shall be thoroughly impregnated with epoxy resin. Fiberglass pipe wall thickness, strength and durability requirements shall be equivalent to the Fiberglass/Epoxy pipe produced by Fiberglass Resources Corporation of Farmingdale, New York or Burgess Well Company, Inc., Minden, Nebraska, telephone (308) 832-1642. All fiberglass pipe and fittings shall be round and straight, of uniform quality and workmanship, and free from all defects including indentation, delamination, bends, cracks, blisters, porosity, dry spots, resin segregation and resin-starved areas. The inside of the pipe and fittings shall be smooth and uniform. The impregnation of the glass fiber with resin shall be such that when the pipe is cut or slotted, no fraying or looseness of glass fiber occurs.
  - a. **Couplings:** Couplings for fiberglass pipe sections shall be socket threaded or mechanical key-type couplings. The couplings shall be manufactured of the same materials used for the fiberglass pipe specified herein and may be either cast integrally with the pipe sections or as separate components for attachment to the pipe in the manufacturers plant. Key-type couplings shall consist of male and female halves designed for joining and locking together by means of a key strip inserted in grooves in the coupling halves. The minimum wall thickness remaining at any grooved section shall not be less than the minimum thickness specified for pipe. Key strips and locking strips shall be of fiberglass, plastic or other non-corrosive material capable of withstanding shearing and bearing stresses equivalent to the design load for the coupling. Socket type fitting connections of the pipe sections shall be bonded with epoxy adhesive. The epoxy materials and bonding agents shall be as recommended by the pipe manufacturer. Self-tapping screws or other devices for holding adhesive-joined pipe in the couplings during the curing period may be utilized. In no case shall a newly-made joint in the casing pipe be lowered into the relief well, or be submerged in water prior to complete curing of the adhesive.
  - b. **Perforations:** All fiberglass well screen shall be mill slot **OR** continuous wire wrapped rod base, **as directed**. All relief well screen shall have smooth, sharp-edged openings free of burrs, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.
3. **Steel Pipe Screen:** Steel well screen shall consist of perforated or slotted sections of steel pipe conforming to the requirements of ASTM A 53.
  - a. **Couplings:** Couplings for steel pipe screen shall be welded joints or threaded couplings. Welding shall be performed in accordance with requirements in ASME B31.9. Couplings shall meet the material requirements specified for steel pipe screen, except perforations shall be omitted. All threaded pipe and fittings shall be threaded in accordance with ASME B1.20.1. All threaded pipe sections may be field connected. Couplings shall be given the same protection against corrosion as specified for the well screen pipe. Protective coatings damaged while making couplings shall have the areas recoated.
  - b. **Perforations:** All steel pipe to be used as relief well screen shall be provided with perforations which shall consist of either machine-cut slots; drilled or punched openings. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe. The pattern of the openings shall be uniformly spaced around the periphery of the pipe.
4. **Stainless Steel Well Screen:** The perforated well screen and fittings shall be fabricated entirely from stainless steel conforming to ASTM A 312/A 312M, Type 304, 304-L, 316 or 316-L. The well screen shall be of stainless steel with a keystone wire-wrapped continuous slot strainer equivalent to that manufactured by Howard Smith Screen Company, Houston, TX, telephone (713) 869-5771 or Johnson Screens, St. Paul, MN 55164, telephone (612) 636-3900.
  - a. **Couplings:** Couplings for the stainless steel well screen shall consist of the same material as the well screen and shall be threaded, flanged, and/or fitted with a welding ring. The

couplings shall conform in design to the couplings recommended by the manufacturer of the well screen.

- b. Tailpipe for Well Screen: The tailpipe for each well screen shall be made of the same material and at least the same minimum thickness as the riser pipe and shall include a bottom plug.
- B. Riser Pipe: The relief well riser pipe material and method of manufacture shall conform to the requirements specified in paragraph WELL SCREEN, except that the screen perforations or opening shall be omitted. The relief well riser pipe diameter and discharge details shall be as directed. Couplings to the well screen and between riser pipe sections shall be as specified in paragraph COUPLING.
- C. Filter Pack: Material for the filter pack around the riser pipes and screens shall be a washed grave, **OR** washed sand **OR** dry processed sand, **as directed**, composed of hard, tough, and durable particles free from adherent coating. The filter pack shall not be crushed stone. The filter pack material shall contain no detrimental quantities of organic matter nor soft, friable, thin, or elongated particles in accordance with the quality requirements in ASTM C 33, Table 1 and Table 3, Class 5S, and in ASTM E 11, Table 1.
- D. Outlet For Relief Well: Check Valve.
  - 1. The check valve shall be a one piece reinforced all rubber (neoprene) check valve with an integral elastomer flange similar and equal to the Red Valve Series 35, manufactured by Red Valve Company, Inc., 700 North Bell Ave., Pittsburgh, PA 15106, telephone (412) 279-0044. The backup ring for the check valve shall be stainless steel. Stainless steel bolts, washers, and nuts shall be used to fasten the valves onto the flanged end of the pipes. The check valve shall be installed with the flared end duck bill in a vertical position.  
**OR**  
Fabricate check valves of brass **OR** stainless steel **OR** aluminum, **as directed**, plate, threaded fasteners and rods. Fabricate sealing disc of silicone sponge rubber free of porous areas, foreign materials, and visible defects.
  - 2. Workmanship and metalwork fabrication of check valves shall be as directed. Install check valves accurately vertically and adjust to the required elevation.
- E. Concrete: Concrete shall conform to the requirements specified in Division 03 Section "Cast-in-place Concrete".

### 1.3 EXECUTION

- A. Drilling: Wells may be drilled by the reverse rotary circulation method or other method approved, which will ensure proper placement of the well screen, riser pipe, and filter pack. Methods which involve radical displacement of the formation, or which may reduce the yield of the well, will not be permitted. Excavated material shall be disposed of as directed.
  - 1. Reverse Circulation Method: If the reverse circulation method is used for drilling wells, all of the drilling fluid shall be removed from the filter pack and the natural pervious formation. If in the opinion of the Owner the walls of the hole above the top of the filter pack require support during development operations, a temporary casing similar to that specified in paragraph TEMPORARY CASING shall be placed so as to extend from the ground surface to at least **3 ft (1 m)** below the top of the filter pack. The diameter of the hole shall be such as will permit the placement of the minimum thickness of filter pack as specified in paragraph FILTER PACK PLACEMENT. The drilling fluid shall be a suspension of fine grained soil or shall be a commercial product of a recognized manufacturer, shall be approved by the Owner, and shall have the characteristic of being readily removable from the filter pack and the walls of the formation by development as specified in paragraph DEVELOPMENT. The use of bentonite will not be permitted.
  - 2. Temporary Casing: Temporary well casing of either iron or steel of sufficient length to case to the bottom of all borings shall be available at the construction site. the Owner will direct the use of a temporary casing to the bottom of the boring during drilling and placement of screen, riser, and

filter pack when it believes it is necessary to provide adequate support to the sides of the hole. When the walls of the boring will require support only during development operations a temporary casing will be required to extend only to a depth **3 ft (3 m)** below the top of the filter pack. The temporary casing, shall have sufficient thickness to retain its shape and maintain a true section throughout its depth, and may be in sections of any convenient length. The temporary casing shall be such as to permit its removal without disturbing the filter pack, riser, or well screen. The setting of temporary casing shall be such that no cavity will be created outside of it at any point along its length. In the event the temporary casing should become unduly distorted or bent it shall be discarded and a new casing shall be used during installation of any additional relief wells.

**B. Installation Of Riser Pipe And Screen**

1. **Assembly:** All riser pipe and screen shall be in good condition before installation and all couplings and other accessory parts shall be securely fastened in place. The successive lengths of pipe shall be arranged to provide accurate placement of the screen sections in the bore hole. The riser-pipe shall be provided with an approved cap and a flanged top section, the top of which shall be set at the elevation directed. Centralizers shall be attached to the assembled riser pipe and screen in such numbers and of a type that they will satisfactorily center the riser pipe and screen in the well and will hold it securely in position while the filter pack material is being placed.
2. **Joints:** Sections of relief well pipe shall be joined together as specified in paragraph **COUPLINGS**. Joints shall be designed and constructed to have the strength of the pipe and where possible a strength capable to support the weight of the relief well stem as it is lowered into the hole. When not practicable to construct joints that will support the weight of the relief well stem, the stem shall be supported at the lower end by any approved means that will assure that the joints do not open while being lowered into place in the well.
3. **Installation:** The assembled riser pipe and screen shall be placed in the bore hole in such manner as to avoid jarring impacts and to ensure that the assembly is centered and not damaged or disconnected. The screen shall be suspended in the hole and not resting on the bottom of the hole. After the screen and riser pipe have been placed, a filter pack shall be constructed around the screen section as specified in paragraph **FILTER PACK PLACEMENT** and the well developed as specified in paragraph **DEVELOPMENT**. The top of the riser pipe shall be held at the designated elevation during placement of the filter pack.
4. **Check for Plumbness and Alignment:** The well shall be constructed and all casing set round, plumb, and true. The Contractor shall perform the following tests after the installation of the well but prior to backfilling, and before its acceptance. Additional tests may be made during the performance of the work at the option of the Contractor. Should the Contractor fail to correct, at no additional cost to the Owner, any faulty alignment or plumbness disclosed as a result of these tests, the Owner may refuse to accept the well. the Owner may waive the requirements for plumbness if in its judgement the Contractor has exercised all possible care in constructing the well and the defect is due to circumstances beyond its control or if the utility of the completed well is not materially affected or if the cost of necessary remedial measures will be excessive. In no event will the provisions with respect to alignment be waived.
  - a. **Plumbness:** Plumbness shall be tested by use of a plumb line. The plummet shall be suspended from a small diameter wire rope and its point of suspension shall be in the exact center of the plummet. The plummet shall be sufficiently heavy to stretch the wire rope taut. The wire rope shall pass over a guide sheave which shall be positioned above the top of the well and adjusted horizontally so that the plummet hangs in the center of the well. Displacement of the wire rope during the plumbness check shall be measured by means of a transparent plastic sheet on which a number of concentric circles shall be scribed or drawn, and which is centered on the top of the well. The exact center of these circles shall be marked, and then a slot, slightly larger than the plumb line and extending from this center to the edge, shall be cut in the plastic sheet. As the plummet is lowered, any out-of-plumb condition of the well will be indicated by the wire rope tending to drift away from the center, and the plastic sheet shall be rotated until the slot is oriented in the direction of this drift, while at all times maintaining the center of the concentric circles coincident with the center of the well. Measurement of the amount of drift shall be made

- along the edge of the slot for each increment by which the plummet is lowered into the well. Drift at any depth shall be determined by multiplying the measured plumb line displacement by the total length of the plumb line and dividing the result by the fixed distance between the guide sheave and the top of the well. If desired, alignment may be calculated from the plumbness data in lieu of the alignment check described in paragraph ALIGNMENT. Should the well vary from the vertical in excess of allowable, the plumbness of the well shall be corrected by the Contractor at no additional cost to the Owner.
- b. Alignment: Alignment shall be tested by lowering into the well a section of cylinder or a dummy of the same length. The outside diameter of cylinder shall be smaller than the inside diameter of the well. Should the cylinder fail to move freely throughout the length of the well, the alignment of the well shall be corrected by the Contractor at no additional expense to the Owner.
- C. Filter Pack Placement: After the well screen and riser pipe have been installed, the filter pack material shall be placed by tremie, when using a well graded material, in an approved manner such that segregation will not occur. When using a uniform graded filter material, the material may be poured around the well screen at a rate that will prevent bridging of the material. The material shall be placed around all sides of the screen to assure that the screen is not pushed against the side of the bore hole causing the screen to come in contact with foundation material or prevent the proper thickness of filter from being placed uniformly around the screen. The filter pack shall be placed at a constant rate from the start of placement until it has reached the elevation directed. If a tremie is required, a double string of tremie pipe shall be used. The pipes shall be placed on opposite sides of the screen and/or casing, that is, 180 degrees apart, and shall be guided in such a manner that they will remain in this position throughout the placing process. The tremie pipes shall be set in place, filled completely with filter pack prior to being lifted off the bottom of the hole. The filter pack in the tremie pipe shall be kept above the water surface in the well throughout the placing process. In no case shall the gradation of the filter pack fall outside of the range specified in paragraph FILTER PACK.
- D. Development
1. General: Following placement of filter pack materials, the Contractor shall develop the relief well by jetting, surging, intermittent pumping, or other approved methods as may be necessary to give the maximum yield of water. At the time of development of any relief well, the well shall be free of drawdown or surcharge effects due to pump testing, developing or drilling at another location. The Contractor shall be responsible for maintaining at the relief well the needed access and work area and clearance in the relief well necessary to accomplish development. The Contractor shall furnish, install, or construct the necessary discharge line and troughs to conduct and dispose of the discharge a sufficient distance from the work areas to prevent damage. Development shall be conducted to achieve a stable well of maximum efficiency and shall be continued until a satisfactory sand test, as specified in paragraph SAND TEST, is obtained. As development proceeds, filter pack material shall be added to the annular space around the screen to maintain the top elevation of the filter pack to the specified elevation. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well under all conditions. If at any time during the development process it becomes apparent in the opinion of the Owner that the well may be damaged, development operations shall be immediately terminated. the Owner may require a change in method if the method selected does not accomplish the desired results. the Owner may order that wells which continue to produce excessive amounts of fines after development for 6 hours be abandoned, plugged, and backfilled, and may require the Contractor to construct new wells nearby. All materials pulled into the well by the development process shall be removed prior to performing the pumping test.
- a. Jetting: Jetting should be performed using either a single or double ring jet. The jetting tool shall be constructed of high-strength material and conservatively designed and proportioned so that it will withstand high pressures. The jetting tool shall have two hydraulically balanced nozzles spaced 180 degrees **OR** four diameter holes spaced 90 degrees, **as directed**, apart and which shall exert the jetting force horizontally through the screen slots. The rings shall be constructed such that the tips of the jets shall be within **1/2 in. (13 mm)** from the inner surface of the well screen. The pump used in conjunction with

the jetting tool shall be capable of providing a minimum jetting fluid exit velocity of **150 feet per second (45 meters per second)**. Prior to commencing jetting, and following each jetting cycle, all sand and/or other materials shall be removed from inside the screen. All wells shall be pumped during the jetting cycle to remove incoming sand and other material. Such pumping shall be at a rate not less than 115 percent of the rate at which fluid is introduced through the jetting tool. This will allow a flow of material into the well as it is being developed. Water used for development shall be free of sand. the Owner may require other means of developing the well such as intermittent pumping method, variation of the intermittent pumping method, or surge block if it appears that the development of the well is not producing the desired results.

- b. Intermittent Pumping: Intermittent pumping shall be performed by pumping the well at a capacity sufficient to produce a rapid drawdown, stopping the pump (backflow through pump will not be permitted) to permit the water surface to rise to its former elevation, and repeating this procedure. Cycle time for this procedure will vary as directed but will not be more than 3 cycles per minute. A deep well turbine pump, or electric submersible pump with check valve, shall be used with any attachment necessary to accomplish rapid starting and stopping for intermittent pumping. The intake shall be set below the maximum expected drawdown in the well. Prior to commencing intermittent pumping, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. The amount of drawdown may be decreased if, in the opinion of the Owner, the efficiency of the well might otherwise be impaired.
  - c. Surging: Surging of the well shall require use of a circular block which is smaller in diameter than the inside diameter of the relief well and is constructed of a material which will not damage the screen if the block comes in contact with the screen, and a bailer or pump to remove materials drawn into the well. The surging shall be continued for a period of approximately one hour or until little or no additional material from the foundation or filter pack can be pulled through the screen. The surge block shall be moved by a steady motion up and down the full length of the well screen. Prior to commencing surging, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. All materials pulled into the well by the surging process shall be removed by the Contractor.
- E. Backfilling: After the well has been developed, additional filter pack shall be added if necessary to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the annular space above the filter pack, shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with grout or concrete. The concrete backfill shall be placed to a depth at least equal to the existing impervious blanket. For PVC riser pipe, after the well has been developed, additional filter pack shall be added if necessary for it to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the remaining annular space above the filter pack shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with bentonite. The temporary casing, if used, shall be withdrawn in increments as the backfill is placed. The Contractor shall fill with impervious material to original grade all pits such as those incidental to the reverse rotary circulation method of drilling.
- F. Plugging Of Abandoned Wells: The Contractor has the option of attempting to remove the well screen. If the well screen can be removed, the Contractor will grout the bore hole starting from the bottom of the hole. The grouting shall start at the elevation of the bottom of the tailpipe of the well. If the well screen can not be removed or breaks off during the removal attempt, the Contractor shall still be responsible for grouting the well from the bottom of the tailpipe to within **3 ft (1 m)** of ground surface. Either of the above abandonment procedures may require the Contractor to redrill the hole so that the bore hole can be grouted. The well shall be grouted from the bottom of the tailpipe. After the grout has setup the riser pipe shall be cutoff. Then the hole shall be backfilled. The cement grout mixture proportion to be used shall be submitted for approval.



G. Tests

1. Pump Test: Upon completion but before acceptance, each well shall be subjected to a pump test of which a sand test will form a part. The Contractor shall provide a deep well turbine pump, capable of producing the specified drawdowns over periods of time sufficient to satisfactorily perform the pump test specified herein. The intake shall be set below the maximum expected drawdown in the well. The amount of sand shall be measured after each test. The pump shall be complete with either gasoline, diesel, or electric motor of adequate size. In case an electric motor is used, the Contractor shall provide, without additional cost to the Owner, the electric power and the necessary wiring. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well. The Contractor shall furnish and install an orifice meter of approved design or other approved equipment for the purpose of measuring the discharge from the well during the pumping test. The Contractor shall furnish, install, or construct the necessary pipe discharge line, troughs, or ditches necessary to dispose of the pumping test discharge a sufficient distance from the work area to prevent damage. The tests will be conducted under the direction of the Owner and may be made as soon as each well is completed. Test data will be recorded by the Owner. The Contractor shall test each well by pumping continuously for a minimum of 6 hours. Prior to starting the pump test all material shall be removed from the bottom of the well. If the test is interrupted, other than by order of the Owner, prior to the completion of the specified period of continuous operation, the test shall be re-run. In addition to the required pumping test, the Owner may direct the Contractor to perform additional pump tests. Such additional testing shall conform in general to the requirements specified herein except that the duration of the tests and the approximate draw-down will be determined by the Owner. In the event that sand or other material collects in the well as a result of the pump test, accurate measurements shall be taken as to the quantity of material in the well and all such material shall be removed by the Contractor. Upon completion of the pump test, the Contractor shall remove all equipment, discharge lines, electrical lines, lumber, and debris, and shall backfill any excavated areas with impervious material.
2. Sand Test: As part of each Pump Test or at the end of each intermittent pumping a determination of the amount of sand (filter pack and/or foundation material) a well is producing shall be performed. Prior to starting the sand test all material shall be removed from the bottom of the tailpipe. After the pump is at the desired pumping rate the flow from the discharge shall be diverted into a container that will collect all the sand being carried by the water **OR** through a Rossum Sand Tester, **as directed**. Upon completion of the test the amount of sand in the tailpipe shall be determined to verify that no material is being deposited in the bottom of the well.
3. Filter Pack Sampling and Testing: The Contractor shall verify that all materials conform to the specifications before delivery to the project. The particle size distribution of the filter pack shall be sampled and tested by the Contractor in accordance with ASTM C 136 and ASTM D 75. Within 48 hours before being placed in the relief well to be back-filled, the filter pack shall be sampled from the material stockpiled at the project site. There shall be at least one particle size distribution test on the filter pack for each well. A pump test shall be performed in accordance with technical provisions herein specified.
4. Reports: Reports shall include, for each relief well, logs of the boring, elevations of the well screen, top of riser pipe, bottom of the tailpipe, filter pack gradation, quantity of filter pack added during development, pump test, sand test, and report of backfilling. The log of backfill material shall include the filter pack particle size distribution test data, and notes concerning installation and development of the relief well. The pump test log shall include the duration of the test and the draw-down response data with time in the pumped well, in adjacent wells, and in nearby piezometers. The relief well log and the pump test log shall be submitted to the Owner. The Contractor shall also submit a report of the well installation to the appropriate public agency and in the form required by state statutory and/or regulatory requirements specified in paragraph REGULATORY REQUIREMENTS.

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## SECTION 23 11 23 00a - MONITORING WELLS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for monitoring wells including drilling, casing, well screen, gravel packing, grouting, development, monitoring device, and incidental related work complete and ready for operation. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. General Requirements

1. Each system, including equipment, materials, installation, and performance, shall be in accordance with local, State, and Federal regulations, ASTM D 5092, and EPA 600-4-89-034 except as modified herein. Consider the advisory or recommended provisions to be mandatory, as though the word "shall" has been substituted for the word "should" wherever it appears. Reference to the "Project Representative" and the "Owner" shall be interpreted to mean the Owner. Additional requirements are included under Division 01 Section "Temporary Facilities And Controls". Mark and secure monitoring wells to avoid unauthorized access and tampering.

#### C. Submittals:

1. Shop Drawings: Well construction.
2. Product Data
  - a. Well casing
  - b. Well screen
  - c. Filter pack
  - d. Neat cement grout
  - e. Bentonite seal
3. Certificates
  - a. Well Drilling/Development Material Handling Plan
  - b. Health and Safety Plan
  - c. Field Sampling and Laboratory Testing Plan
  - d. Treatment facility permit
  - e. Installation Survey Report
  - f. Well Development Report
  - g. Borehole Analysis Report
4. Closeout Submittals
  - a. Well Construction Permit
  - b. Shipment manifests
  - c. Delivery certificates
  - d. Treatment and disposal certificates

#### D. Delivery, Storage, And Handling

1. Deliver materials in an undamaged condition. Unload and store with minimal handling. Store materials in on-site enclosures or under protective coverings. Store plastic piping and jointing materials, and rubber gaskets under cover, out of direct sunlight. Store materials off the ground. Keep insides of pipes and fittings free of dirt and debris. Replace defective or damaged materials with new materials.

#### E. Quality Assurance

1. Required Drawings: Submit well construction drawings showing components and details of well casing, well screen, filter pack, annular seal, and associated items. Drawings shall be prepared by a State certified professional geologist or hydrogeologist, or by a State registered professional



civil engineer, hereafter referred to as the Contractor's Professional Consultant (CPC). Drawings shall be sealed.

2. Well Drilling/Development Material Handling Plan: A material handling plan shall be furnished by the Contractor 15 days prior to initiation of the work that describes phases of dealing with the potentially contaminated soil and groundwater, including the following: a schedule to be employed in the well drilling and development stages, a sequence of operations, the method of drilling and development, material hauling, proposed equipment, handling of the contaminated materials, soil and water testing requirements, and safety precautions and requirements.
3. Health and Safety Plan (HASP): Describe safety precautions for each phase of the project as specifically related to handling of soil and water removed during well drilling and development operations. Identify appropriate requirements of 29 CFR 1910 and COE EM-385-1-1. Identify safety equipment and procedures to be available and used during the project. Furnish the name and qualifications based on education, training, and work experience of the proposed Health and Safety Officer (HASO) and the members of the drill crew. The CPC may perform the responsibilities of the HASO if properly qualified.
4. Field Sampling and Laboratory Testing Plan: Describe field sampling methods and quality control procedures. Identify laboratory and laboratory methods to be used for contamination testing. Sample reports shall show sample identification for location, date, time, sample method, contamination level, name of individual sampler, identification of laboratory, and quality control procedures.
5. Treatment Facility Permit: Verification that the proposed treatment facility is permitted to accept the contaminated materials specified, prior to the start of excavation.
6. Well Development Report: Provide report, containing the following data for each well: project name and location, well designation, date and time of well installation, date and time of well development, static water level from top of well casing before development and 24 hours after development, field measurements of pH, temperature, and specific conductivity, depth of well from top of casing to bottom of well, screen length, description of development methodology size/capacity of pump or bailer, pumping rate, and recharge rate.
7. Well Construction Permit: Submit a completed permit application and a proposed method of construction to the appropriate state agency prior to construction of the well. Construction of the wells will not be allowed until an approved Well Construction Permit has been submitted to the Owner.
8. Shipment Manifests: Copies of manifests and other documentation required for shipment of waste materials within 24 hours after removal of waste from the site. Shipment manifests shall be signed by the Owner.
9. Delivery Certificates: Verification that the wastes were actually delivered to the approved treatment facility, within 7 days of shipment.
10. Treatment and Disposal Certificates: Verification that the wastes were successfully treated and remediated to the levels specified herein.

## 1.2 PRODUCTS

### A. Well Casing

1. Stainless Steel Piping: ASTM A 312/A 312M, Type 304, Schedule 40S, with flush threaded joint end fittings. Threaded joints shall be wrapped with fluoropolymer tape, and provided with nitrile O-ring gaskets.
2. PVC Piping: ASTM F 480, Type 1, Grade 1, PVC 12454, NSF wc or NSF pw, Schedule 40 **OR** 80, **as directed**, with flush threaded joint fittings. Threaded joints shall be wrapped with fluoropolymer tape, and provided with nitrile O-ring gaskets.

- B. Well Screen: Well screens shall be located as directed. The length of each screen shall be as directed. Slot size shall be as required to meet project requirements. Slotted openings shall be distributed uniformly around the circumference of the screen. Open area shall approach the formation's natural porosity.

1. Stainless Steel Screens: ASTM A 312/A 312M, Type 304, Schedule 40S, continuous slot construction, wire wound, with flush threaded joint ends.
  2. PVC Screens: ASTM D 1785, PVC 1120, NSF wc or NSF pw, Schedule 40 **OR** 80, **as directed**, screen, Schedule 80, machine-slotted construction, flush threaded joint ends. Slots shall be even in width, length, and separation.
- C. Primary Filter Pack: Provide clean, durable, well-rounded, and washed quartz or granite, with less than 5 percent non-siliceous material. The filter pack shall not contain organic matter or friable materials. The filter pack shall allow free flow of water in the well, and shall prevent the infiltration of aquifer materials. Filter pack shall have a 30 percent finer than (d-30) grain size size as required to meet project requirements, and a uniformity coefficient less than 2.5, in accordance with ASTM C 117 and ASTM C 136.
- D. Secondary Filter Pack: Gradation in accordance with ASTM D 5092. Provide clean, durable, well-rounded, and washed quartz or granite. Pack shall not contain organic matter or friable materials.
- E. Annular Sealants
1. Bentonite Seal: Provide powdered, granular, pelletized, or chipped sodium **OR** calcium, **as directed**, montmorillonite in sealed containers from a commercial source, free of impurities. Diameter of pellets shall be less than one fifth the diameter of the borehole annular space to prevent bridging. Bentonite base grout shall be in accordance with ASTM D 5092.
  2. Neat Cement Grout: Provide neat cement grout in accordance with ASTM D 5092. Cement shall be in accordance with ASTM C 150. Quick setting admixtures shall not be allowed. Drilling mud or cuttings shall not be used as a sealing material.
- F. Bottom Plugs: Provide flush threaded solid plug at the bottom of the well. Plug shall be the same material as the well casing **OR** screen to which it is attached, **as directed**. Joints shall be wrapped with fluoropolymer tape and provided with nitrile O-ring gaskets.
- G. Locking Well Cap: Provide flush threaded, weatherproof, and non-removable locking well cap on the top of the well. Well cap shall be of the same material as the well casing to which it is attached. Well cap shall accommodate padlock. Provide a long shackled padlock in accordance with ASTM F 883. Provide two keys for the padlock, and turn them over to the Owner. Locks at the well site shall be keyed alike.
- H. Well Head Completions: Clearly mark and secure the well to avoid unauthorized access and tampering. Cast the words "MONITORING WELL" on the well head cover. Provide a sign reading, "WELL IS FOR MONITORING AND IS NOT SAFE FOR DRINKING." Provide stamped metal identification tag as follows:
- DO NOT DISTURB
- ID #: \_\_\_\_\_ Date: \_\_\_\_\_
- Installed By: \_\_\_\_\_
- Total Depth: \_\_\_\_\_
- Screened Interval: \_\_\_\_\_
- TOC Elevation: \_\_\_\_\_
- Other: \_\_\_\_\_
- For Information, Call: \_\_\_\_\_
1. Aboveground Completions: Provide protective outer casing around the well casing extending above grade. The diameter of the protective outer casing shall be a minimum of 4 in. (100 mm) larger than the well casing diameter. The top of the protective outer casing shall extend a minimum of 6 in. (150 mm) above the top of the well casing cap. The protective outer casing shall be set in cement grout and the bottom of the protective well casing shall extend below the depth of the frost line **OR** to the depth indicated, **as directed**. A 1/4 in. (6 mm) diameter weep hole shall be drilled in the protective outer casing 3 in. (75 mm) above the ground surface. The annular space between the protective outer casing and the well casing shall be filled with pea gravel or coarse sand to just below the level of the cap on the well casing. The locking well cap



shall be provided on top of the protective outer casing. Provide **6 in. (150 mm)** diameter steel pipe bollards, filled with concrete as indicated to protect the exposed well head.

- a. Protective Outer Casing and Bollards: ASTM A 53, Type E or S, Grade B.
  - b. Well Casing Cap: Provide cap on top of the protective outer casing. Cap shall be flush threaded and of the same material as the protective outer casing. Threaded joints shall be wrapped with fluoropolymer tape and provided with nitrile O-ring gaskets.
2. At-Grade Completions: Provide cast iron **OR** aluminum, **as directed**, vault box, **30 by 30 in. (750 by 750 mm) OR 12 in. (300 mm)** diameter, **as directed**, with watertight frame and cover. Vault shall support H-20 loading for traffic areas **OR** a **100,000 lb. (45,360 kg)** loading for airfield locations, **as directed**. The frame shall be **6 in. (150 mm)** deep, and shall be set in a concrete collar a minimum of **8 in. (200 mm)** thick, and extending **4 in. (100 mm)** beyond the edge of the frame in all directions. Frame and concrete collar shall be set flush with the level of the existing pavement **OR** set **3 in. (75 mm)** above the existing grade, **as directed**. Locking well cap shall be provided on top of the well casing, which will terminate inside the vault as indicated.

- I. Polyethylene Sheeting: ASTM D 4397.

### 1.3 EXECUTION

- A. General: Notify the Owner at least 15 days prior to commencement of work. Locations of wells shall be as indicated. Drilling, installation, and development of the monitoring wells shall be supervised, directed, and monitored by the CPC. Drilling, sampling, and well development equipment introduced to the well shall be decontaminated before and after each use in accordance with ASTM D 5088.
- B. Drilling: Borehole shall be advanced using conventional **10 in. (250 mm)** hollow-stem auger **OR** solid auger **OR** rotary wash, **as directed**, drilling methods. If it is the opinion of the CPC that an alternate drilling method is required, justification for a boring method change shall be submitted to the Owner, and approval for the change granted prior to drilling. Drill crew shall be experienced and trained in drilling and safety requirements for contaminated sites.
  1. Sampling: Obtain samples in accordance with ASTM D 1586 or ASTM D 1587. Perform standard penetration tests at the following depths **0.0 to 1.5 ft (0 to 450 mm); 1.5 to 3.0 ft (450 to 900 mm); 3.0 to 4.5 ft (900 to 1350 mm); and 5 ft (1500 mm)** centers or at changes in soil formation thereafter. Each soil sample shall be screened in the field with an organic vapor analyzer/flame ionization device (OVA/FID) capable of detecting vapors to a minimum of one ppm. Log boring in accordance with ASTM D 2487 and ASTM D 2488. Groundwater elevation shall be indicated.
  2. Analysis: The CPC shall review the log data from each borehole and compare the data with the well design requirements. The CPC shall verify the adequacy of the well design, or shall offer a proposed modification to the design based on the geologic and hydrogeologic data obtained from the borehole. This review and analysis shall be conducted for each borehole **OR** for one borehole considered representative of the entire project, **as directed**. The CPC shall submit the borehole boring logs, the analysis of the well design, and any proposed design modifications to the Owner in a Borehole Analysis Report. Any modifications to the well design approved by the Owner shall be considered a change to the contract documents and shall be negotiated in accordance with the "CHANGES" clause.
  3. Alignment: Verify that the well is straight by lowering a **10 ft (3 m)** section of steel pipe **1/4 in. (6 mm)** smaller in diameter than the inside diameter of the casing in to the well. For wells deeper than **200 ft (60 m)**, Contractor shall verify that the well is plumb.
- C. Soil Removed From The Borehole
  1. Temporary Containment of Soil Removed from the Borehole: Soil removed from the borehole shall be placed in a temporary containment area. Provide a temporary containment area near the well site. Cover containment area with **10 mil (0.25 mm)** reinforced polyethylene sheeting. Place soil removed from the borehole[s] on the impervious barrier and cover with **6 mil (0.15 mm)** reinforced polyethylene sheeting. Provide a straw bale berm around the outer limits of the

containment area and cover with polyethylene sheets. Secure edges of sheets with weights to keep the polyethylene sheeting in place. Water runoff shall be diverted from the stockpiled material. As an option, soil may be stockpiled in trucks suitable for transporting contaminated soils as specified herein.

2. Testing Requirements for Stockpiled Soils

a. Sampling: A minimum of one composite sample shall be developed and analyzed for each required test for every 100 cu. yds. (76.4 cu. m) or fraction thereof from a composite stockpile of soil removed from all well sites. To develop a composite sample of the size necessary to run the required tests, the Contractor shall take several samples from different areas along the surface and in the center of the stockpile. These samples shall be combined and thoroughly mixed to develop the composite sample.

b. Testing

- 1) The soil shall contain no free liquid as demonstrated by EPA SW-846, Method 9095, paint filter liquids test.
- 2) The sum of benzene, toluene, ethyl benzene, and xylene (BTEX) concentrations shall be determined by using EPA SW-846, Method 5030/8020.
- 3) TPH (total petroleum hydrocarbons) concentrations shall be determined by using EPA SW-846, Method 8015, which has been modified for use with soil.
- 4) Material shall be tested for TOX (total organic halogens) in accordance with EPA SW-846, Method 9020.
- 5) Material shall be analyzed for full TCLP in accordance with EPA SW-846, Method 1311 and for ignitability, corrosivity, and reactivity.
- 6) Material shall be tested for polychlorinated biphenyls (PCB's) in accordance with EPA SW-846, Method 8080.
- 7) Moisture content of the sample shall be determined in accordance with EPA Method 160.3.

c. Disposal of Stockpiled Soils

- 1) Soils exhibiting TPH less than 100 ppm, BTEX less than 10 ppm, TOX less than 100 ppm, passing TCLP tests, and testing negative for PCB's shall be considered clean as shall be disposed of on-site, as directed by the Owner.
- 2) Soils failing the TCLP test or exhibiting TOX greater than 100 ppm shall be managed in accordance with applicable State and local regulations. Payment for disposal of materials failing the TCLP metals test or TOX test shall be made in accordance with the "CHANGES" clause of the General Conditions.
- 3) If the concentration of total BTEX is greater than 10 ppm or TPH greater than 100 ppm, the soil shall be treated and disposed of at a permitted soil recycling facility.

D. Well Installation: Well installation shall be in accordance with ASTM D 5092 and EPA 600-4-89-034, and as indicated on the well construction drawings submitted by the CPC and approved by the Owner. Borehole shall be stable and shall be verified straight before beginning installation.

1. Casings and Screens: Well casings, screens, plugs, and caps shall be decontaminated prior to delivery by the manufacturer and shall be certified clean. Materials shall be delivered, stored, and handled in such manner as to ensure that grease, oil, or other contaminants do not contact any portion of the well screen and casing assembly prior to installation. If directed by the Owner, the well screen and casing assembly shall be cleaned with high pressure water prior to installation. Personnel shall wear clean cotton or surgical gloves while handling the assembly. Centralizers shall be used to ensure that the well screen and casing assembly is installed concentrically in the borehole. When the assembly has been installed at the appropriate elevation, it shall be adequately secured to preclude movement during placement of the filter packs and annular seals. The top of the well casing shall be capped during filter pack placement.
2. Primary and Secondary Filter Packs: Primary and secondary filter packs shall be placed as indicated on the approved well construction drawings to fill the entire annular space between the screen and casing assembly and the outside wall of the borehole. Place both the primary and secondary filters with a tremie pipe in accordance with EPA 600-4-89-034 and ASTM D 5092. Placement of the primary and secondary filters by gravity or free fall methods is not allowed. Control speed of filter placement to prevent bridging and to allow for settlement. Prior to



- commencement of work, equipment and methods required to place filters shall be approved by the Owner.
3. Bentonite Seal: Bentonite shall be placed as a slurry through a tremie pipe. Control speed of bentonite placement to prevent bridging or segregation of slurry. Additional water shall be added to the annular space as directed by the CPC to ensure complete hydration of the bentonite. Bentonite shall cure a minimum of 48 hours before the placement of cement grout to ensure complete hydration and expansion of the bentonite.
  4. Neat Cement Grout: Cement grout shall be placed in the annular space above the bentonite seal as indicated on the well construction drawings. Cement grout shall be placed as a slurry through a tremie pipe, and injected under pressure to reduce chance of voids. Grout shall be injected in one continuous operation until full strength grout flows out at the ground surface without evidence of drilling cuttings or fluid. Cement grout shall cure a minimum of 48 hours before beginning well development operations.
  5. Well Head Completions: Well head completions shall be as indicated and as specified herein.
- E. Well Development: Well development shall be in accordance with EPA 600-4-89-034 and ASTM D 5092 except as modified herein. Bailing, surging, and pumping/overpumping/backwashing are acceptable development methods. Air surging and jetting are prohibited. Method of development shall be chosen by the CPC and approved by the Owner. Well development shall not begin until the well installation is complete and accepted by the Owner. Well development operations shall be conducted continuously until development water flows clear and free of drilling fluids, cuttings, or other materials. At such time representative water samples shall be tested for pH, temperature, and specific conductivity in accordance with EPA 600-4-79-20. Samples shall be taken every 3 hours. When stabilized readings of these parameters, as accepted by the Owner, have been achieved for 12 consecutive hours, well development operations shall cease.
- F. Water From Well Development Operations: Water from the well development operations shall be containerized in accordance with State and local regulations. One sample shall be taken and analyzed for each required test for every 1000 gallons (3780 liters) of stored water from well development operations.
1. Testing
    - a. The sum of benzene, toluene, ethyl benzene, and xylene (BTEX) concentrations shall be determined by using EPA SW-846, Method 8020.
    - b. TPH (total petroleum hydrocarbons) concentrations shall be determined by using EPA SW-846, Method 8015.
  2. Disposal of Containerized Water
    - a. Water exhibiting TPH less than 0.5 ppm and BTEX less than 1 ppb shall be considered clean and shall be disposed of on-site as directed by the Owner.
    - b. If the concentration of total BTEX is greater than 1 ppb or TPH greater than 0.5 ppm, the water shall be treated and disposed of at a permitted facility.
- G. Transportation Of Contaminated Soil And Water: The Contractor shall be solely responsible for complying with Federal, State, and local requirements for transporting contaminated materials through the applicable jurisdictions and shall bear responsibility and cost for any noncompliance. In addition to those requirements, the Contractor shall do the following:
1. Inspect and document vehicles and containers for proper operation and covering.
  2. Inspect vehicles and containers for proper markings, manifest documents, and other requirements for waste shipment.
  3. Perform and document decontamination procedures prior to leaving the worksite and again before leaving the disposal site.
- H. Disposal Of Contaminated Soil And Water: Contaminated materials removed from the site shall be disposed of in a treatment/disposal facility permitted to accept such materials.



- I. Installation Survey: Upon completion of well installation and development and acceptance by the Owner therefor, the Contractor vertical and horizontal position of each well shall be determined by a registered land surveyor licensed in the State where the work is located . The survey shall document the vertical elevations of the top of the casing pipe and the ground surface elevation adjacent to each well. Survey shall be accurate to the nearest 0.01 ft (3 mm). This data shall be submitted with a well location map as the Installation Survey Report.
- J. Cleanup: Upon completion of the well construction, remove debris and surplus materials from the jobsite.

END OF SECTION 23 11 23 00a

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## SECTION 23 11 23 00b - FACILITY NATURAL-GAS PIPING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for facility natural gas piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Pipes, tubes, and fittings.
  - b. Piping specialties.
  - c. Piping and tubing joining materials.
  - d. Valves.
  - e. Pressure regulators.
  - f. Service meters.
  - g. Mechanical sleeve seals.
  - h. Grout.
  - i. Concrete bases.

#### C. Definitions

1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

#### D. Performance Requirements

1. Minimum Operating-Pressure Ratings:
  - a. Piping and Valves: 100 psig (690 kPa) minimum unless otherwise indicated.
  - b. Service Regulators: 65 psig (450 kPa) OR 100 psig (690 kPa), as directed, minimum unless otherwise indicated.
  - c. Minimum Operating Pressure of Service Meter: 5 psig (34.5 kPa) OR 10 psig (69 kPa) OR 20 psig (138 kPa) OR 65 psig (450 kPa), as directed.
2. Natural-Gas System Pressure within Buildings: 0.5 psig (3.45 kPa) or less OR More than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa) OR More than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa), as directed.  
OR  
Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa), and is reduced to secondary pressure of 0.5 psig (3.45 kPa) or less.  
OR  
Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa), and is reduced to secondary pressure of more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa).  
OR  
Natural-Gas System Pressures within Buildings: Three pressure ranges. Primary pressure is more than 2 psig (13.8 kPa) but not more than 5 psig (34.5 kPa), and is reduced to secondary pressures of more than 0.5 psig (3.45 kPa) but not more than 2 psig (13.8 kPa), and is reduced again to pressures of 0.5 psig (3.45 kPa) or less.



3. Delegated Design: Design restraints and anchors for natural-gas piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For facility natural-gas piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
3. Delegated-Design Submittal: For natural-gas piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Detail fabrication and assembly of seismic restraints.
  - b. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Welding certificates.
5. Field quality-control reports.
6. Operation and maintenance data.

F. Quality Assurance

1. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

G. Delivery, Storage, And Handling

1. Handling Flammable Liquids: Remove and dispose of liquids from existing natural-gas piping according to requirements of authorities having jurisdiction.
2. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
3. Store and handle pipes and tubes having factory-applied protective coatings to avoid damaging coating, and protect from direct sunlight.
4. Protect stored PE pipes and valves from direct sunlight.

H. Project Conditions

1. Interruption of Existing Natural-Gas Service: Do not interrupt natural-gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural-gas supply according to requirements indicated:
  - a. Notify Owner no fewer than two days in advance of proposed interruption of natural-gas service.
  - b. Do not proceed with interruption of natural-gas service without Owner's written permission.

## 1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  - a. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
  - b. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
  - c. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.

- d. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
  - 1) Material Group: 1.1.
  - 2) End Connections: Threaded or butt welding to match pipe.
  - 3) Lapped Face: Not permitted underground.
  - 4) Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
  - 5) Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless steel underground.
- e. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
  - 1) Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
- f. Mechanical Couplings:
  - 1) Stainless-steel **OR** Steel, **as directed**, flanges and tube with epoxy finish.
  - 2) Buna-nitrile seals.
  - 3) Stainless-steel **OR** Steel, **as directed**, bolts, washers, and nuts.
  - 4) Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
  - 5) Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.
2. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
  - a. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
  - b. Coating: PE with flame retardant.
    - 1) Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
      - a) Flame-Spread Index: 25 or less.
      - b) Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
  - c. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
  - d. Striker Plates: Steel, designed to protect tubing from penetrations.
  - e. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
  - f. Operating-Pressure Rating: **5 psig (34.5 kPa)**.
3. Aluminum Tubing: Comply with ASTM B 210 and ASTM B 241/B 241M.
  - a. Aluminum Alloy: Alloy 5456 is prohibited.
  - b. Protective Coating: Factory-applied coating capable of resisting corrosion on tubing in contact with masonry, plaster, insulation, water, detergents, and sewerage.
  - c. Flare Fittings: Comply with ASME B16.26 and SAE J513.
    - 1) Copper-alloy fittings.
    - 2) Metal-to-metal compression seal without gasket.
    - 3) Dryseal threads shall comply with ASME B1.20.3.
4. Drawn-Temper Copper Tube: Comply with **ASTM B 88, Type K (ASTM B 88M, Type A) OR ASTM B 88, Type L (ASTM B 88M, Type B) OR** ASTM B 837, Type G, **as directed**.
  - a. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
  - b. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
    - 1) Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    - 2) Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
  - c. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of **0.022 inch (0.56 mm)** thick.
5. Annealed-Temper Copper Tube: Comply with **ASTM B 88, Type K (ASTM B 88M, Type A) OR ASTM B 88, Type L (ASTM B 88M, Type B) OR** ASTM B 837, Type G, **as directed**.
  - a. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
  - b. Flare Fittings: Comply with ASME B16.26 and SAE J513.

- 1) Copper fittings with long nuts.
- 2) Metal-to-metal compression seal without gasket.
- 3) Dryseal threads complying with ASME B1.20.3.
- c. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of **0.022 inch (0.56 mm)** thick.
6. Tin-Lined Copper Tube: ASTM B 280, seamless, annealed, with interior tin-plated lining.
  - a. Flare Fittings: Comply with ASME B16.26 and SAE J513.
    - 1) Copper fittings with long nuts.
    - 2) Metal-to-metal compression seal without gasket.
    - 3) Dryseal threads complying with ASME B1.20.3.
7. PE Pipe: ASTM D 2513, SDR 11.
  - a. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
  - b. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  - c. Anodeless Service-Line Risers: Factory fabricated and leak tested.
    - 1) Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
    - 2) Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground, **as directed**.
    - 3) Aboveground Portion: PE transition fitting.
    - 4) Outlet shall be threaded or flanged or suitable for welded connection.
    - 5) Tracer wire connection.
    - 6) Ultraviolet shield.
    - 7) Stake supports with factory finish to match steel pipe casing or carrier pipe.
  - d. Transition Service-Line Risers: Factory fabricated and leak tested.
    - 1) Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
    - 2) Outlet shall be threaded or flanged or suitable for welded connection.
    - 3) Bridging sleeve over mechanical coupling.
    - 4) Factory-connected anode.
    - 5) Tracer wire connection.
    - 6) Ultraviolet shield.
    - 7) Stake supports with factory finish to match steel pipe casing or carrier pipe.
  - e. Plastic Mechanical Couplings, **NPS 1-1/2 (DN 40)** and Smaller: Capable of joining PE pipe to PE pipe.
    - 1) PE body with molded-in, stainless-steel support ring.
    - 2) Buna-nitrile seals.
    - 3) Acetal collets.
    - 4) Electro-zinc-plated steel stiffener.
  - f. Plastic Mechanical Couplings, **NPS 2 (DN 50)** and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    - 1) Fiber-reinforced plastic body.
    - 2) PE body tube.
    - 3) Buna-nitrile seals.
    - 4) Acetal collets.
    - 5) Stainless-steel bolts, nuts, and washers.
  - g. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    - 1) Stainless-steel **OR Steel, as directed**, flanges and tube with epoxy finish.
    - 2) Buna-nitrile seals.
    - 3) Stainless-steel **OR Steel, as directed**, bolts, washers, and nuts.
    - 4) Factory-installed anode for steel-body couplings installed underground.

B. Piping Specialties

1. Appliance Flexible Connectors:
  - a. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
  - b. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
  - c. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
  - d. Corrugated stainless-steel tubing with polymer coating.
  - e. Operating-Pressure Rating: **0.5 psig (3.45 kPa)**.
  - f. End Fittings: Zinc-coated steel.
  - g. Threaded Ends: Comply with ASME B1.20.1.
  - h. Maximum Length: **72 inches (1830 mm)**.
2. Quick-Disconnect Devices: Comply with ANSI Z21.41.
  - a. Copper-alloy convenience outlet and matching plug connector.
  - b. Nitrile seals.
  - c. Hand operated with automatic shutoff when disconnected.
  - d. For indoor or outdoor applications.
  - e. Adjustable, retractable restraining cable.
3. Y-Pattern Strainers:
  - a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
  - b. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
  - c. Strainer Screen: **40 OR 60, as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
  - d. CWP Rating: **125 psig (862 kPa)**.
4. Basket Strainers:
  - a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
  - b. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
  - c. Strainer Screen: **40 OR 60, as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
  - d. CWP Rating: **125 psig (862 kPa)**.
5. T-Pattern Strainers:
  - a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
  - b. End Connections: Grooved ends.
  - c. Strainer Screen: **40 OR 60, as directed**, -mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
  - d. CWP Rating: **750 psig (5170 kPa)**.
6. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

C. Joining Materials

1. Joint Compound and Tape: Suitable for natural gas.
2. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
3. Brazing Filler Metals: Alloy with melting point greater than **1000 deg F (540 deg C)** complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

D. Manual Gas Shutoff Valves

1. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
2. General Requirements for Metallic Valves, **NPS 2 (DN 50)** and Smaller: Comply with ASME B16.33.
  - a. CWP Rating: **125 psig (862 kPa)**.



- b. Threaded Ends: Comply with ASME B1.20.1.
  - c. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
  - d. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - e. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves **1 inch (25 mm)** and smaller.
  - f. Service Mark: Valves **1-1/4 inches (32 mm)** to **NPS 2 (DN 50)** shall have initials "WOG" permanently marked on valve body.
3. General Requirements for Metallic Valves, **NPS 2-1/2 (DN 65)** and Larger: Comply with ASME B16.38.
  - a. CWP Rating: **125 psig (862 kPa)**.
  - b. Flanged Ends: Comply with ASME B16.5 for steel flanges.
  - c. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - d. Service Mark: Initials "WOG" shall be permanently marked on valve body.
4. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Ball: Chrome-plated brass.
  - c. Stem: Bronze; blowout proof.
  - d. Seats: Reinforced TFE; blowout proof.
  - e. Packing: Separate packnut with adjustable-stem packing threaded ends.
  - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - g. CWP Rating: **600 psig (4140 kPa)**.
  - h. Listing: Valves **NPS 1 (DN 25)** and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
5. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Ball: Chrome-plated bronze.
  - c. Stem: Bronze; blowout proof.
  - d. Seats: Reinforced TFE; blowout proof.
  - e. Packing: Threaded-body packnut design with adjustable-stem packing.
  - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - g. CWP Rating: **600 psig (4140 kPa)**.
  - h. Listing: Valves **NPS 1 (DN 25)** and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
6. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Ball: Chrome-plated bronze.
  - c. Stem: Bronze; blowout proof.
  - d. Seats: Reinforced TFE.
  - e. Packing: Threaded-body packnut design with adjustable-stem packing.
  - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - g. CWP Rating: **600 psig (4140 kPa)**.
  - h. Listing: Valves **NPS 1 (DN 25)** and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
7. Bronze Plug Valves: MSS SP-78.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Plug: Bronze.



- c. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
- d. Operator: Square head or lug type with tamperproof feature where indicated.
- e. Pressure Class: 125 psig (862 kPa).
- f. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
- g. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- 8. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
  - a. Body: Cast iron, complying with ASTM A 126, Class B.
  - b. Plug: Bronze or nickel-plated cast iron.
  - c. Seat: Coated with thermoplastic.
  - d. Stem Seal: Compatible with natural gas.
  - e. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - f. Operator: Square head or lug type with tamperproof feature where indicated.
  - g. Pressure Class: 125 psig (862 kPa).
  - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- 9. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
  - a. Body: Cast iron, complying with ASTM A 126, Class B.
  - b. Plug: Bronze or nickel-plated cast iron.
  - c. Seat: Coated with thermoplastic.
  - d. Stem Seal: Compatible with natural gas.
  - e. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - f. Operator: Square head or lug type with tamperproof feature where indicated.
  - g. Pressure Class: 125 psig (862 kPa).
  - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for natural-gas service with "WOG" indicated on valve body.
- 10. PE Ball Valves: Comply with ASME B16.40.
  - a. Body: PE.
  - b. Ball: PE.
  - c. Stem: Acetal.
  - d. Seats and Seals: Nitrile.
  - e. Ends: Plain or fusible to match piping.
  - f. CWP Rating: 80 psig (552 kPa).
  - g. Operating Temperature: Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C).
  - h. Operator: Nut or flat head for key operation.
  - i. Include plastic valve extension.
  - j. Include tamperproof locking feature for valves where indicated on Drawings.
- 11. Valve Boxes:
  - a. Cast-iron, two-section box.
  - b. Top section with cover with "GAS" lettering.
  - c. Bottom section with base to fit over valve and barrel a minimum of 5 inches (125 mm) in diameter.
  - d. Adjustable cast-iron extensions of length required for depth of bury.
  - e. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head, and with stem of length required to operate valve.

E. Motorized Gas Valves

- 1. Automatic Gas Valves: Comply with ANSI Z21.21.
  - a. Body: Brass or aluminum.
  - b. Seats and Disc: Nitrile rubber.
  - c. Springs and Valve Trim: Stainless steel.

- d. Normally closed.
- e. Visual position indicator.
- f. Electrical **OR** Mechanical, **as directed**, operator for actuation by appliance automatic shutoff device.
- 2. Electrically Operated Valves: Comply with UL 429.
  - a. Pilot operated.
  - b. Body: Brass or aluminum.
  - c. Seats and Disc: Nitrile rubber.
  - d. Springs and Valve Trim: Stainless steel.
  - e. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
  - f. NEMA ICS 6, Type 4, coil enclosure.
  - g. Normally closed.
  - h. Visual position indicator.

F. Earthquake Valves

- 1. Earthquake Valves: Comply with ASCE 25.
  - a. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - b. Maximum Operating Pressure: **5 psig (34.5 kPa)**.
  - c. Cast-aluminum body with nickel-plated chrome steel internal parts.
  - d. Nitrile-rubber valve washer.
  - e. Sight windows for visual indication of valve position.
  - f. Threaded end connections complying with ASME B1.20.1.
  - g. Wall mounting bracket with bubble level indicator.
- 2. Earthquake Valves: Comply with ASCE 25.
  - a. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - b. Maximum Operating Pressure: **0.5 psig (3.45 kPa) OR 7 psig (48 kPa) OR 60 psig (414 kPa), as directed**.
  - c. Cast-aluminum body with stainless-steel internal parts.
  - d. Nitrile-rubber, reset-stem o-ring seal.
  - e. Valve position, open or closed, indicator.
  - f. Composition valve seat with clapper held by spring or magnet locking mechanism.
  - g. Level indicator.
  - h. End Connections: Threaded for valves **NPS 2 (DN 50)** and smaller; flanged for valves **NPS 2-1/2 (DN 65)** and larger.

G. Pressure Regulators

- 1. General Requirements:
  - a. Single stage and suitable for natural gas.
  - b. Steel jacket and corrosion-resistant components.
  - c. Elevation compensator.
  - d. End Connections: Threaded for regulators **NPS 2 (DN 50)** and smaller; flanged for regulators **NPS 2-1/2 (DN 65)** and larger.
- 2. Service Pressure Regulators: Comply with ANSI Z21.80.
  - a. Body and Diaphragm Case: Cast iron or die-cast aluminum.
  - b. Springs: Zinc-plated steel; interchangeable.
  - c. Diaphragm Plate: Zinc-plated steel.
  - d. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
  - e. Orifice: Aluminum; interchangeable.
  - f. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
  - g. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
  - h. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
  - i. Overpressure Protection Device: Factory mounted on pressure regulator.

- j. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
    - k. Maximum Inlet Pressure: **100 psig (690 kPa)**.
  - 3. Line Pressure Regulators: Comply with ANSI Z21.80.
    - a. Body and Diaphragm Case: Cast iron or die-cast aluminum.
    - b. Springs: Zinc-plated steel; interchangeable.
    - c. Diaphragm Plate: Zinc-plated steel.
    - d. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
    - e. Orifice: Aluminum; interchangeable.
    - f. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
    - g. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
    - h. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
    - i. Overpressure Protection Device: Factory mounted on pressure regulator.
    - j. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
    - k. Maximum Inlet Pressure: **2 psig (13.8 kPa) OR 5 psig (34.5 kPa) OR 10 psig (69 kPa), as directed.**
  - 4. Appliance Pressure Regulators: Comply with ANSI Z21.18.
    - a. Body and Diaphragm Case: Die-cast aluminum.
    - b. Springs: Zinc-plated steel; interchangeable.
    - c. Diaphragm Plate: Zinc-plated steel.
    - d. Seat Disc: Nitrile rubber.
    - e. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
    - f. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
    - g. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
    - h. Maximum Inlet Pressure: **1 psig (6.9 kPa) OR 2 psig (13.8 kPa) OR 5 psig (34.5 kPa), as directed.**
- H. Service Meters
  - 1. Diaphragm-Type Service Meters: Comply with ANSI B109.1 **OR** ANSI B109.2, **as directed.**
    - a. Case: Die-cast aluminum.
    - b. Connections: Steel threads.
    - c. Diaphragm: Synthetic fabric.
    - d. Diaphragm Support Bearings: Self-lubricating.
    - e. Compensation: Continuous temperature and pressure, **as directed.**
    - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed.**
    - g. Meter Case and Index: Tamper resistant.
    - h. Remote meter reader compatible.
    - i. Maximum Inlet Pressure: **100 psig (690 kPa)**.
    - j. Pressure Loss: Maximum **0.5-inch wg (124 Pa) OR 2.0-inch wg (498 Pa), as directed.**
    - k. Accuracy: Maximum plus or minus 1.0 percent.
  - 2. Rotary-Type Service Meters: Comply with ANSI B109.3.
    - a. Case: Extruded aluminum.
    - b. Connection: Flange.
    - c. Impellers: Polished aluminum.
    - d. Rotor Bearings: Self-lubricating.
    - e. Compensation: Continuous temperature and pressure, **as directed.**
    - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed.**
    - g. Tamper resistant.
    - h. Remote meter reader compatible.
    - i. Maximum Inlet Pressure: **100 psig (690 kPa)**.
    - j. Accuracy: Maximum plus or minus 2.0 percent.

3. Turbine Meters: Comply with ASME MFC-4M.
    - a. Housing: Cast iron or welded steel.
    - b. Connection Threads or Flanges: Steel.
    - c. Turbine: Aluminum or plastic.
    - d. Turbine Bearings: Self-lubricating.
    - e. Compensation: Continuous temperature and pressure, **as directed**.
    - f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed**.
    - g. Tamper resistant.
    - h. Remote meter reader compatible.
    - i. Maximum Inlet Pressure: **100 psig (690 kPa)**.
    - j. Accuracy: Maximum plus or minus 2.0 percent.
  4. Service-Meter Bars:
    - a. Malleable- or cast-iron frame for supporting service meter.
    - b. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
    - c. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.
  5. Service-Meter Bypass Fittings:
    - a. Ferrous, tee, pipe fitting with capped side inlet for temporary natural-gas supply.
    - b. Integral ball-check bypass valve.
- I. Dielectric Fittings
1. Dielectric Unions:
    - a. Minimum Operating-Pressure Rating: **150 psig (1034 kPa)**.
    - b. Combination fitting of copper alloy and ferrous materials.
    - c. Insulating materials suitable for natural gas.
    - d. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
  2. Dielectric Flanges:
    - a. Minimum Operating-Pressure Rating: **150 psig (1034 kPa)**.
    - b. Combination fitting of copper alloy and ferrous materials.
    - c. Insulating materials suitable for natural gas.
    - d. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
  3. Dielectric-Flange Kits:
    - a. Minimum Operating-Pressure Rating: **150 psig (1034 kPa)**.
    - b. Companion-flange assembly for field assembly.
    - c. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
    - d. Insulating materials suitable for natural gas.
    - e. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
- J. Sleeves
1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
  2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- K. Mechanical Sleeve Seals
1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
    - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
    - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**.

- c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.
  - L. Escutcheons
    - 1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.
    - 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
    - 3. One-Piece, Cast-Brass Escutcheons: With set screw.
      - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
    - 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
      - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
    - 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
    - 6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
    - 7. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.
    - 8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.
  - M. Grout
    - 1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
      - a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
      - b. Design Mix: **5000-psi (34.5-MPa)**, 28-day compressive strength.
      - c. Packaging: Premixed and factory packaged.
  - N. Labeling And Identifying
    - 1. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of **6 inches (150 mm)** wide and **4 mils (0.1 mm)** thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to **30 inches (750 mm)** deep; colored yellow.
- 1.3 EXECUTION
- A. Preparation
    - 1. Close equipment shutoff valves before turning off natural gas to premises or piping section.
    - 2. Inspect natural-gas piping according to NFPA 54 **OR** the International Fuel Gas Code, **as directed**, to determine that natural-gas utilization devices are turned off in piping section affected.
    - 3. Comply with NFPA 54 **OR** the International Fuel Gas Code, **as directed**, requirements for prevention of accidental ignition.
  - B. Outdoor Piping Installation
    - 1. Comply with NFPA 54 **OR** the International Fuel Gas Code, **as directed**, for installation and purging of natural-gas piping.
    - 2. Install underground, natural-gas piping buried at least **36 inches (900 mm)** below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
      - a. If natural-gas piping is installed less than **36 inches (900 mm)** below finished grade, install it in containment conduit.
    - 3. Install underground, PE, natural-gas piping according to ASTM D 2774.
    - 4. Steel Piping with Protective Coating:
      - a. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.





- b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

**OR**

Replace pipe having damaged PE coating with new pipe.

- 5. Copper Tubing with Protective Coating:
  - a. Apply joint cover kits over tubing to cover, seal, and protect joints.
  - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
- 6. Install fittings for changes in direction and branch connections.
- 7. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
  - a. Install steel pipe for sleeves smaller than **6 inches (150 mm)** in diameter.
  - b. Install cast-iron "wall pipes" for sleeves **6 inches (150 mm)** and larger in diameter.
- 8. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- 9. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- 10. Install pressure gage downstream **OR** upstream and downstream, **as directed**, from each service regulator. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".

C. Indoor Piping Installation

- 1. Comply with NFPA 54 **OR** the International Fuel Gas Code, **as directed**, for installation and purging of natural-gas piping.
- 2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- 3. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- 4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- 5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- 6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- 7. Locate valves for easy access.
- 8. Install natural-gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- 9. Install piping free of sags and bends.
- 10. Install fittings for changes in direction and branch connections.
- 11. Install escutcheons at penetrations of interior walls, ceilings, and floors.
  - a. New Piping:
    - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    - 2) Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.

**OR**

Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.

  - 3) Piping at Ceiling Penetrations in Finished Spaces: One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.

**OR**

- Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
- 4) Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.  
**OR**  
Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
  - 5) Piping in Equipment Rooms: One-piece, cast-brass type.  
  
Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
  - 6) Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- b. Existing Piping:
- 1) Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.  
**OR**  
Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
  - 2) Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.  
**OR**  
Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
  - 3) Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.  
**OR**  
Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
  - 4) Piping in Equipment Rooms: Split-casting, cast-brass type.  
**OR**  
Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
  - 5) Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
  13. Verify final equipment locations for roughing-in.
  14. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
  15. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
    - a. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than **3 inches (75 mm)** long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
  16. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
  17. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
  18. Concealed Location Installations: Except as specified below, install concealed natural-gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.





- a. Above Accessible Ceilings: Natural-gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
  - b. In Floors: Install natural-gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of **1-1/2 inches (38 mm)** of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
  - c. In Floor Channels: Install natural-gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
  - d. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
    - 1) Exception: Tubing passing through partitions or walls does not require striker barriers.
  - e. Prohibited Locations:
    - 1) Do not install natural-gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
    - 2) Do not install natural-gas piping in solid walls or partitions.
  19. Use concentric reducer fittings to make reductions in pipe sizes.
  20. Connect branch piping from top or side of horizontal piping.
  21. Install unions in pipes **NPS 2 (DN 50)** and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
  22. Do not use natural-gas piping as grounding electrode.
  23. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
  24. Install pressure gage downstream **OR** upstream and downstream, **as directed**, from each line regulator. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".
- D. Service-Meter Assembly Installation
1. Install service-meter assemblies aboveground, on concrete bases.
  2. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.
  3. Install strainer on inlet of service-pressure regulator and meter set.
  4. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
  5. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
  6. Install service meters downstream from pressure regulators.
  7. Install metal bollards to protect meter assemblies. Comply with requirements in Division 05 Section "Metal Fabrications" for pipe bollards.
- E. Valve Installation
1. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
  2. Install underground valves with valve boxes.
  3. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
  4. Install earthquake valves aboveground outside buildings according to listing.
  5. Install anode for metallic valves in underground PE piping.
- F. Piping Joint Construction
1. Ream ends of pipes and tubes and remove burrs.
  2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
  3. Threaded Joints:

- a. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
    - b. Cut threads full and clean using sharp dies.
    - c. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
    - d. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
    - e. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
  4. Welded Joints:
    - a. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
    - b. Bevel plain ends of steel pipe.
    - c. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
  5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
  6. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural-gas service. Install gasket concentrically positioned.
  7. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
  8. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
    - a. Plain-End Pipe and Fittings: Use butt fusion.
    - b. Plain-End Pipe and Socket Fittings: Use socket fusion.
- G. Hanger And Support Installation
1. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  2. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
  3. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
    - a. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
    - b. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
    - c. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
    - d. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
    - e. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (15.8 mm).
  4. Install hangers for horizontal drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
    - a. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
    - b. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
    - c. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches (2134 mm); minimum rod size, 3/8 inch (10 mm).
    - d. NPS 1 (DN 25): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).
  5. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
    - a. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).



- b. **NPS 1/2 (DN 15):** Maximum span, **72 inches (1830 mm)**; minimum rod size, **3/8 inch (10 mm)**.
- c. **NPS 3/4 (DN 20) and Larger:** Maximum span, **96 inches (2440 mm)**; minimum rod size, **3/8 inch (10 mm)**.

#### H. Connections

1. Connect to utility's gas main according to utility's procedures and requirements.
2. Install natural-gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
3. Install piping adjacent to appliances to allow service and maintenance of appliances.
4. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within **72 inches (1800 mm)** of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
5. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

#### I. Labeling And Identifying

1. Comply with requirements in Division 23 Section "Identification For Hvac Piping And Equipment" for piping and valve identification.  
**OR**  
Install detectable warning tape directly above gas piping, **12 inches (300 mm)** below finished grade, except **6 inches (150 mm)** below subgrade under pavements and slabs.

#### J. Painting

1. Comply with requirements in Division 07 for painting interior and exterior natural-gas piping.
2. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
  - a. Alkyd System: MPI EXT 5.1D.
    - 1) Prime Coat: Alkyd anticorrosive metal primer.
    - 2) Intermediate Coat (for a Premium Grade system): Exterior alkyd enamel matching topcoat.
    - 3) Topcoat: Exterior alkyd enamel (flat) **OR** (semigloss) **OR** (gloss), **as directed**.
    - 4) Color: Gray, **unless directed otherwise**.
3. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory-applied paint or protective coating.
  - a. Latex Over Alkyd Primer System: MPI INT 5.1Q.
    - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
    - 2) Intermediate Coat (for a Premium Grade system): Interior latex matching topcoat.
    - 3) Topcoat: Interior latex (flat) **OR** (low sheen) **OR** (eggshell) **OR** (satin) **OR** (semigloss) **OR** (gloss), **as directed**.
    - 4) Color: Gray, **unless directed otherwise**.
  - b. Alkyd System: MPI INT 5.1E.
    - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
    - 2) Intermediate Coat (for a Premium Grade system): Interior alkyd matching topcoat.
    - 3) Topcoat: Interior alkyd (flat) **OR** (eggshell) **OR** (semigloss) **OR** (gloss), **as directed**.
    - 4) Color: Gray, **unless directed otherwise**.
4. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

#### K. Concrete Bases

1. Concrete Bases: Anchor equipment to concrete base according to seismic codes at Project.
  - a. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit.

- b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of the base.
  - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
  - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - f. Use **3000-psig (20.7-MPa)**, **unless directed otherwise**, 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
- L. Field Quality Control
  - 1. Perform tests and inspections.
  - 2. Tests and Inspections:
    - a. Test, inspect, and purge natural gas according to NFPA 54 **OR** the International Fuel Gas Code, **as directed**, and authorities having jurisdiction.
  - 3. Natural-gas piping will be considered defective if it does not pass tests and inspections.
  - 4. Prepare test and inspection reports.
- M. Outdoor Piping Schedule
  - 1. Underground natural-gas piping shall be one of the following:
    - a. PE pipe and fittings joined by heat fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
    - b. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
    - c. Annealed **OR** Drawn, **as directed**,-temper copper tube with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
  - 2. Aboveground natural-gas piping shall be one of the following:
    - a. Steel pipe with malleable-iron fittings and threaded joints.
    - b. Steel pipe with wrought-steel fittings and welded joints.
    - c. Annealed **OR** Drawn, **as directed**,-temper copper tube with wrought-copper fittings and brazed joints.
  - 3. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper tube with wrought-copper fittings and brazed **OR** flared, **as directed**, joints. Install piping embedded in concrete with no joints in concrete.
  - 4. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- N. Indoor Piping Schedule For System Pressures Less Than **0.5 psig (3.45 kPa)**
  - 1. Aboveground, branch piping **NPS 1 (DN 25)** and smaller shall be one of the following:
    - a. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
    - b. Annealed-temper, tin-lined copper tube with flared joints and fittings.
    - c. Annealed-temper, copper tube with wrought-copper fittings and brazed **OR** flared, **as directed**, joints.
    - d. Aluminum tube with flared fittings and joints.
    - e. Steel pipe with malleable-iron fittings and threaded joints.
  - 2. Aboveground, distribution piping shall be one of the following:
    - a. Steel pipe with malleable-iron fittings and threaded joints.
    - b. Steel pipe with wrought-steel fittings and welded joints.
    - c. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
  - 3. Underground, below building, piping shall be one of the following:
    - a. Steel pipe with malleable-iron fittings and threaded joints.
    - b. Steel pipe with wrought-steel fittings and welded joints.
  - 4. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.



5. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- O. Indoor Piping Schedule For System Pressures More Than 0.5 psig (3.45 kPa) And Less Than 5 psig (34.5 kPa)
1. Aboveground, branch piping NPS 1 (DN 25) and smaller shall be one of the following:
    - a. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
    - b. Annealed-temper, tin-lined copper tube with flared joints and fittings.
    - c. Annealed-temper, copper tube with wrought-copper fittings and brazed **OR** flared, **as directed**, joints.
    - d. Aluminum tube with flared fittings and joints.
    - e. Steel pipe with malleable-iron fittings and threaded joints.
  2. Aboveground, distribution piping shall be one of the following:
    - a. Steel pipe with malleable-iron fittings and threaded joints.
    - b. Steel pipe with steel welding fittings and welded joints.
    - c. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
  3. Underground, below building, piping shall be one of the following:
    - a. Steel pipe with malleable-iron fittings and threaded joints.
    - b. Steel pipe with wrought-steel fittings and welded joints.
  4. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.
  5. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- P. Indoor Piping Schedule For System Pressures More Than 5 psig (34.5 kPa)
1. Aboveground Piping: Maximum operating pressure more than 5 psig (34.5 kPa).
  2. Aboveground, Branch Piping: Steel pipe with steel welding fittings and welded joints.
  3. Aboveground, distribution piping shall be one of the following:
    - a. Steel pipe with steel welding fittings and welded joints.
    - b. Drawn-temper copper tube with wrought-copper fittings and brazed joints.
  4. Underground, below building, piping shall be one of the following:
    - a. Steel pipe with malleable-iron fittings and threaded joints.
    - b. Steel pipe with wrought-steel fittings and welded joints.
  5. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
  6. Containment Conduit Vent Piping: Steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- Q. Underground Manual Gas Shutoff Valve Schedule
1. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
  2. Underground:
    - a. PE valves.
    - b. NPS 2 (DN 50) and Smaller: Bronze plug valves.
    - c. NPS 2-1/2 (DN 65) and Larger: Cast-iron, lubricated **OR** nonlubricated, **as directed**, plug valves.
- R. Aboveground Manual Gas Shutoff Valve Schedule
1. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be one of the following:
    - a. One-piece, bronze ball valve with bronze trim.
    - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.



- c. Bronze plug valve.
2. Valves for pipe sizes **NPS 2-1/2 (DN 65)** and larger at service meter shall be one of the following:
  - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - b. Bronze plug valve.
  - c. Cast-iron, nonlubricated plug valve.
3. Distribution piping valves for pipe sizes **NPS 2 (DN 50)** and smaller shall be one of the following:
  - a. One-piece, bronze ball valve with bronze trim.
  - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - c. Bronze plug valve.
4. Distribution piping valves for pipe sizes **NPS 2-1/2 (DN 65)** and larger shall be one of the following:
  - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - b. Bronze plug valve.
  - c. Cast-iron, nonlubricated **OR** lubricated, **as directed**, plug valve.
5. Valves in branch piping for single appliance shall be one of the following:
  - a. One-piece, bronze ball valve with bronze trim.
  - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - c. Bronze plug valve.

END OF SECTION 23 11 23 00b

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## SECTION 23 11 23 00c - FACILITY LIQUEFIED-PETROLEUM GAS PIPING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for facility liquid-petroleum gas piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Pipes, tubes, and fittings.
  - b. Piping specialties.
  - c. Piping and tubing joining materials.
  - d. Valves.
  - e. Pressure regulators.
  - f. Service meters.
  - g. Storage containers.
  - h. Transport truck unloading facility specialties.
  - i. Pumps.
  - j. Vaporizers.
  - k. Air mixers.
  - l. Mechanical sleeve seals.
  - m. Grout.
  - n. Concrete bases.

#### C. Definitions

1. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. LPG: Liquefied-petroleum gas.

#### D. Performance Requirements

1. Minimum Operating-Pressure Ratings:
  - a. For Piping Containing Only Vapor:
    - 1) Piping and Valves: **125 psig (862 kPa)** unless otherwise indicated.
  - b. For Piping Containing Liquid:
    - 1) Piping between Shutoff Valves: **350 psig (2413 kPa)** unless otherwise indicated.
    - 2) Piping Other Than Above: **250 psig (1723 kPa)** unless otherwise indicated.
    - 3) Valves and Fittings: **250 psig (1723 kPa)** unless otherwise indicated.
  - c. Minimum Operating Pressure of Service Meter: **5 psig (34.5 kPa) OR 10 psig (69 kPa) OR 20 psig (138 kPa) OR 65 psig (450 kPa), as directed.**
2. LPG System Pressure within Buildings: One pressure range. **0.5 psig (3.45 kPa)** or less **OR** More than **0.5 psig (3.45 kPa)** but not more than **2 psig (13.8 kPa) OR** More than **2 psig (13.8 kPa)** but not more than **5 psig (34.5 kPa), as directed.**  
**OR**  
LPG System Pressures within Buildings: Two pressure ranges. Primary pressure is more than **0.5 psig (3.45 kPa)** but not more than **2 psig (13.8 kPa)** and is reduced to secondary pressure of **0.5 psig (3.45 kPa)** or less.

**OR**

LPG System Pressures within Buildings: Two pressure ranges. Primary pressure is more than **2 psig (13.8 kPa)** but not more than **5 psig (34.5 kPa)** and is reduced to secondary pressure of more than **0.5 psig (3.45 kPa)** but not more than **2 psig (13.8 kPa)**.

**OR**

LPG System Pressures within Buildings: Three pressure ranges. Primary pressure is more than **2 psig (13.8 kPa)** but not more than **5 psig (34.5 kPa)** and is reduced to secondary pressures of more than **0.5 psig (3.45 kPa)** but not more than **2 psig (13.8 kPa)** and is reduced again to pressures of **0.5 psig (3.45 kPa)** or less.

3. Delegated Design: Design restraints and anchors for LPG piping and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
4. Seismic Performance: Vaporizers and storage container supports shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

**E. Submittals**

1. Product Data: For each type of product indicated.
2. Shop Drawings: For facility LPG piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
3. Delegated-Design Submittal: For LPG piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Detail fabrication and assembly of seismic restraints.
  - b. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Seismic Qualification Certificates: Submit certification that vaporizer, air mixer, storage container supports, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Welding certificates.
6. Field quality-control reports.
7. Operation and maintenance data.

**F. Quality Assurance**

1. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

**G. Delivery, Storage, And Handling**

1. Handling Flammable Liquids: Remove and dispose of liquids from existing LPG piping according to requirements of authorities having jurisdiction.
2. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

3. Store pipes and tubes with protective PE coating to avoid damaging coating and protect from direct sunlight.
4. Protect stored PE pipes and valves from direct sunlight.

H. Project Conditions

1. Interruption of Existing LPG Service: Do not interrupt LPG service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of LPG supply according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed interruption of LPG service.
  - b. Do not proceed with interruption of LPG service without the Owner's written permission.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. Steel Pipe: ASTM A 53/A 53M, black steel, Schedules 40 and 80, Type E or S, Grade B.
  - a. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
  - b. Wrought-Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
  - c. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
  - d. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
    - 1) Material Group: 1.1.
    - 2) End Connections: Threaded or butt welding to match pipe.
    - 3) Lapped Face: Not permitted underground.
    - 4) Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    - 5) Bolts and Nuts: ASME B18.2.1, carbon steel aboveground, and stainless steel underground.
  - e. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
    - 1) Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
  - f. Mechanical Couplings:
    - 1) Stainless-steel **OR** Steel, **as directed**, flanges and tube with epoxy finish.
    - 2) Buna-nitrile seals.
    - 3) Stainless-steel **OR** Steel, **as directed**, bolts, washers, and nuts.
    - 4) Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    - 5) Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.
2. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.
  - a. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
  - b. Coating: PE with flame retardant.
    - 1) Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
      - a) Flame-Spread Index: 25 or less.
      - b) Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
  - c. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
  - d. Striker Plates: Steel, designed to protect tubing from penetrations.
  - e. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
  - f. Operating-Pressure Rating: 5 psig (34.5 kPa).

3. Aluminum Tubing: Comply with ASTM B 210 and ASTM B 241/B 241M.
  - a. Aluminum Alloy: Alloy 5456 is prohibited.
  - b. Protective Coating: Factory-applied coating capable of resisting corrosion on tubing in contact with masonry, plaster, insulation, water, detergents, and sewerage.
  - c. Flare Fittings: Comply with ASME B16.26 and SAE J513.
    - 1) Copper-alloy fittings.
    - 2) Metal-to-metal compression seal without gasket.
    - 3) Dryseal threads shall comply with ASME B1.20.3.
4. Drawn-Temper Copper Tube: Comply with **ASTM B 88, Type K (ASTM B 88M, Type A) OR ASTM B 88, Type L (ASTM B 88M, Type B) OR** ASTM B 837, Type G, **as directed**.
  - a. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
  - b. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
    - 1) Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
    - 2) Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
  - c. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of **0.022 inch (0.56 mm)** thick.
5. Annealed-Temper Copper Tube: Comply with **ASTM B 88, Type K (ASTM B 88M, Type A) OR ASTM B 88, Type L (ASTM B 88M, Type B) OR** ASTM B 837, Type G, **as directed**.
  - a. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
  - b. Flare Fittings: Comply with ASME B16.26 and SAE J513.
    - 1) Copper fittings with long nuts.
    - 2) Metal-to-metal compression seal without gasket.
    - 3) Dryseal threads complying with ASME B1.20.3.
  - c. Protective Coating for Underground Tubing: Factory-applied, extruded PE a minimum of **0.022 inch (0.56 mm)** thick.
6. Tin-Lined Copper Tube: ASTM B 280, seamless, annealed, with interior tin-plated lining.
  - a. Flare Fittings: Comply with ASME B16.26 and SAE J513.
    - 1) Copper fittings with long nuts.
    - 2) Metal-to-metal compression seal without gasket.
    - 3) Dryseal threads complying with ASME B1.20.3.
7. PE Pipe: ASTM D 2513, SDR 11.
  - a. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
  - b. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  - c. Anodeless Service-Line Risers: Factory fabricated and leak tested.
    - 1) Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
    - 2) Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B with corrosion-protective coating covering. Vent casing aboveground, **as directed**.
    - 3) Aboveground Portion: PE transition fitting.
    - 4) Outlet shall be threaded or flanged or suitable for welded connection.
    - 5) Tracer wire connection.
    - 6) Ultraviolet shield.
    - 7) Stake supports with factory finish to match steel pipe casing or carrier pipe.
  - d. Transition Service-Line Risers: Factory fabricated and leak tested.
    - 1) Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet connected to steel pipe complying with ASTM A 53/A 53M, Schedule 40, Type E or S, Grade B, with corrosion-protective coating for aboveground outlet.
    - 2) Outlet shall be threaded or flanged or suitable for welded connection.
    - 3) Bridging sleeve over mechanical coupling.
    - 4) Factory-connected anode.
    - 5) Tracer wire connection.

- 6) Ultraviolet shield.
  - 7) Stake supports with factory finish to match steel pipe casing or carrier pipe.
  - e. Plastic Mechanical Couplings, **NPS 1-1/2 (DN 40)** and Smaller: Capable of joining PE pipe to PE pipe.
    - 1) PE body with molded-in, stainless-steel support ring.
    - 2) Buna-nitrile seals.
    - 3) Acetal collets.
    - 4) Electro-zinc-plated steel stiffener.
  - f. Plastic Mechanical Couplings, **NPS 2 (DN 50)** and Larger: Capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    - 1) Fiber-reinforced plastic body.
    - 2) PE body tube.
    - 3) Buna-nitrile seals.
    - 4) Acetal collets.
    - 5) Stainless-steel bolts, nuts, and washers.
  8. Steel Mechanical Couplings: Capable of joining plain-end PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
    - 1) Stainless-steel **OR** Steel, **as directed**, flanges and tube with epoxy finish.
    - 2) Buna-nitrile seals.
    - 3) Stainless-steel **OR** Steel, **as directed**, bolts, washers, and nuts.
    - 4) Factory-installed anode for steel-body couplings installed underground.
- B. Piping Specialties
1. Flexible Piping Joints:
    - a. Approved for LPG service.
    - b. Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
    - c. Minimum working pressure of **250 psig (1723 kPa)** and **250 deg F (121 deg C)** operating temperature.
    - d. Flanged- or threaded-end connections to match equipment connected and shall be capable of minimum **3/4-inch (20-mm)** misalignment.
    - e. Maximum **36-inch (914-mm)** length for liquid LPG lines.
  2. Appliance Flexible Connectors:
    - a. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
    - b. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
    - c. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
    - d. Corrugated stainless-steel tubing with polymer coating.
    - e. Operating-Pressure Rating: **0.5 psig (3.45 kPa)**.
    - f. End Fittings: Zinc-coated steel.
    - g. Threaded Ends: Comply with ASME B1.20.1.
    - h. Maximum Length: **72 inches (1830 mm)**.
  3. Quick-Disconnect Devices: Comply with ANSI Z21.41.
    - a. Copper-alloy convenience outlet and matching plug connector.
    - b. Nitrile seals.
    - c. Hand operated with automatic shutoff when disconnected.
    - d. For indoor or outdoor applications.
    - e. Adjustable, retractable restraining cable.
  4. Y-Pattern Strainers:
    - a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
    - b. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
    - c. Strainer Screen: **40 OR 60, as directed**, -mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
    - d. CWP Rating: **125 psig (862 kPa)**.
  5. Basket Strainers:



- a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
    - b. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
    - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer and perforated stainless-steel basket with 50 percent free area.
    - d. CWP Rating: **125 psig (862 kPa)**.
  6. T-Pattern Strainers:
    - a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
    - b. End Connections: Grooved ends.
    - c. Strainer Screen: 40 **OR** 60, **as directed**, -mesh startup strainer and perforated stainless-steel basket with 57 percent free area.
    - d. CWP Rating: **750 psig (5170 kPa)**.
  7. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.
- C. Joining Materials
1. Joint Compound and Tape: Suitable for LPG.
  2. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
  3. Brazing Filler Metals: Alloy with melting point greater than **1000 deg F (540 deg C)** complying with AWS A5.8/A5.8M.
- D. Manual Gas Shutoff Valves
1. See "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles for where each valve type is applied in various services.
  2. Metallic Valves, **NPS 2 (DN 50)** and Smaller for Liquid Service: Comply with ASME B16.33 and UL 842.
    - a. CWP Rating: **250 psig (1723 kPa)**.
    - b. Threaded Ends: Comply with ASME B1.20.1.
    - c. Socket ends for brazed joints.
    - d. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
    - e. Listing by CSA or agency acceptable to authorities having jurisdiction for valves **1 inch (25 mm)** and smaller.
    - f. Valves **1-1/4 inch (32 mm)** and larger shall be suitable for LPG service, with "WOG" indicated on valve body.
  3. General Requirements for Metallic Valves, **NPS 2 (DN 50)** and Smaller for Vapor Service: Comply with ASME B16.33.
    - a. CWP Rating: **125 psig (862 kPa)**.
    - b. Threaded Ends: Comply with ASME B1.20.1.
    - c. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
    - d. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
    - e. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves **1 inch (25 mm)** and smaller.
    - f. Service Mark: Valves **1-1/4 inch (32 mm)** to **NPS 2 (DN 50)** shall have initials "WOG" permanently marked on valve body.
  4. General Requirements for Metallic Valves, **NPS 2-1/2 (DN 65)** and Larger: Comply with ASME B16.38.
    - a. CWP Rating: **125 psig (862 kPa)**.
    - b. Flanged Ends: Comply with ASME B16.5 for steel flanges.

- c. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - d. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- 5. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Ball: Chrome-plated brass.
  - c. Stem: Bronze; blowout proof.
  - d. Seats: Reinforced TFE; blowout proof.
  - e. Packing: Separate packnut with adjustable-stem packing threaded ends.
  - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - g. CWP Rating: 600 psig (4143 kPa).
  - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
- 6. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Ball: Chrome-plated bronze.
  - c. Stem: Bronze; blowout proof.
  - d. Seats: Reinforced TFE; blowout proof.
  - e. Packing: Threaded-body packnut design with adjustable-stem packing.
  - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - g. CWP Rating: 600 psig (4143 kPa).
  - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
- 7. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Ball: Chrome-plated bronze
  - c. Stem: Bronze; blowout proof.
  - d. Seats: Reinforced TFE.
  - e. Packing: Threaded-body packnut design with adjustable-stem packing.
  - f. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - g. CWP Rating: 600 psig (4140 kPa).
  - h. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
- 8. Bronze Plug Valves: MSS SP-78.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Plug: Bronze.
  - c. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
  - d. Operator: Square head or lug type with tamperproof feature where indicated.
  - e. Pressure Class: 125 psig (862 kPa).
  - f. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - g. Service: Suitable for LPG service with "WOG" indicated on valve body.
- 9. Cast-Iron, Nonlubricated Plug Valves: MSS SP-78.
  - a. Body: Cast iron, complying with ASTM A 126, Class B.
  - b. Plug: Bronze or nickel-plated cast iron.
  - c. Seat: Coated with thermoplastic.
  - d. Stem Seal: Compatible with LPG.
  - e. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.



- f. Operator: Square head or lug type with tamperproof feature where indicated.
  - g. Pressure Class: **125 psig (862 kPa)**.
  - h. Listing: Valves **NPS 1 (DN 25)** and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
  - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
  - 10. Cast-Iron, Lubricated Plug Valves: MSS SP-78.
    - a. Body: Cast iron, complying with ASTM A 126 Class B.
    - b. Plug: Bronze or nickel-plated cast iron.
    - c. Seat: Coated with thermoplastic.
    - d. Stem Seal: Compatible with LPG.
    - e. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" Articles.
    - f. Operator: Square head or lug type with tamperproof feature where indicated.
    - g. Pressure Class: **125 psig (862 kPa)**.
    - h. Listing: Valves **NPS 1 (DN 25)** and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
    - i. Service: Suitable for LPG service with "WOG" indicated on valve body.
  - 11. PE Ball Valves: Comply with ASME B16.40.
    - a. Body: PE.
    - b. Ball: PE.
    - c. Stem: Acetal.
    - d. Seats and Seals: Nitrile.
    - e. Ends: Plain or fusible to match piping.
    - f. CWP Rating: **80 psig (552 kPa)**.
    - g. Operating Temperature: **Minus 20 to plus 140 deg F (Minus 29 to plus 60 deg C)**.
    - h. Operator: Nut or flat head for key operation.
    - i. Include plastic valve extension.
    - j. Include tamperproof locking feature for valves where indicated on Drawings.
  - 12. Valve Boxes:
    - a. Cast-iron, two-section box.
    - b. Top section with cover with "GAS" lettering.
    - c. Bottom section with base to fit over valve and barrel a minimum of **5 inches (125 mm)** in diameter.
    - d. Adjustable cast-iron extensions of length required for depth of bury.
    - e. Include tee-handle, steel operating wrench with socket end fitting valve nut or flat head and with stem of length required to operate valve.
- E. Motorized Gas Valves
- 1. Hydrostatic Relief Valves: Comply with NFPA 58.
    - a. Operating Pressure: **350 psig (2413 kPa)**.
    - b. Body: Brass.
    - c. Spring: Stainless steel.
    - d. Disc and Seat: Nitrile.
    - e. Brass body and stainless-steel, spring-operated valve with resilient rubber disc seat and protective cap.
    - f. Factory set and tested.
    - g. Listing: Valves listed and labeled by an NRTL acceptable to authorities having jurisdiction.
    - h. Valve shall reseal after relieving pressure.
  - 2. Automatic Gas Valves: Comply with ANSI Z21.21.
    - a. Body: Brass or aluminum.
    - b. Seats and Disc: Nitrile rubber.
    - c. Springs and Valve Trim: Stainless steel.
    - d. Normally closed.
    - e. Visual position indicator.

- f. Electrical **OR** Mechanical, **as directed**, operator for actuation by appliance automatic shutoff device.
  3. Electrically Operated Valves: Comply with UL 429.
    - a. Pilot operated.
    - b. Body: Brass or aluminum.
    - c. Seats and Disc: Nitrile rubber.
    - d. Springs and Valve Trim: Stainless steel.
    - e. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, replaceable.
    - f. NEMA ICS 6, Type 4, coil enclosure.
    - g. Normally closed.
    - h. Visual position indicator.
- F. Earthquake Valves
  1. Earthquake Valves: Comply with ASCE 25.
    - a. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
    - b. Maximum Operating Pressure: **5 psig (34.5 kPa)**.
    - c. Cast-aluminum body with nickel-plated chrome steel internal parts.
    - d. Nitrile-rubber valve washer.
    - e. Sight windows for visual indication of valve position.
    - f. Threaded-end connections complying with ASME B1.20.1.
  2. Earthquake Valves: Comply with ASCE 25.
    - a. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction.
    - b. Maximum Operating Pressure: **0.5 psig (3.45 kPa) OR 7 psig (48 kPa) OR 60 psig (414 kPa), as directed**.
    - c. Cast-aluminum body with stainless-steel internal parts.
    - d. Nitrile-rubber, reset-stem o-ring seal.
    - e. Valve position, open or closed, indicator.
    - f. Composition valve seat with clapper held by spring or magnet locking mechanism.
    - g. Level indicator.
    - h. End Connections: Threaded for valves **NPS 2 (DN 50)** and smaller; flanged for valves **NPS 2-1/2 (DN 65)** and larger.
- G. Pressure Regulators
  1. General Requirements:
    - a. Single stage and suitable for LPG.
    - b. Steel jacket and corrosion-resistant components.
    - c. Elevation compensator.
    - d. End Connections: Threaded for regulators **NPS 2 (DN 50)** and smaller; flanged for regulators **NPS 2-1/2 (DN 65)** and larger.
  2. Service Pressure Regulators: Comply with ANSI Z21.80.
    - a. Body and Diaphragm Case: Cast iron or die-cast aluminum.
    - b. Springs: Zinc-plated steel; interchangeable.
    - c. Diaphragm Plate: Zinc-plated steel.
    - d. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
    - e. Orifice: Aluminum; interchangeable.
    - f. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
    - g. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure sensing piping external to the regulator.
    - h. Pressure regulator shall maintain discharge pressure setting downstream and not exceed 150 percent of design discharge pressure at shutoff.
    - i. Overpressure Protection Device: Factory mounted on pressure regulator.
    - j. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
    - k. Maximum Inlet Pressure: **100 psig (690 kPa)**.
  3. Line Pressure Regulators: Comply with ANSI Z21.80.

- a. Body and Diaphragm Case: Cast iron or die-cast aluminum.
  - b. Springs: Zinc-plated steel; interchangeable.
  - c. Diaphragm Plate: Zinc-plated steel.
  - d. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
  - e. Orifice: Aluminum; interchangeable.
  - f. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
  - g. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet and no pressure sensing piping external to the regulator.
  - h. Pressure regulator shall maintain discharge pressure setting downstream and not exceed 150 percent of design discharge pressure at shutoff.
  - i. Overpressure Protection Device: Factory mounted on pressure regulator.
  - j. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
  - k. Maximum Inlet Pressure: **2 psig (13.8 kPa) OR 5 psig (34.5 kPa) OR 10 psig (69 kPa), as directed.**
4. Appliance Pressure Regulators: Comply with ANSI Z21.18.
- a. Body and Diaphragm Case: Die-cast aluminum.
  - b. Springs: Zinc-plated steel; interchangeable.
  - c. Diaphragm Plate: Zinc-plated steel.
  - d. Seat Disc: Nitrile rubber.
  - e. Seal Plug: Ultraviolet-stabilized, mineral-filled nylon.
  - f. Factory-Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
  - g. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
  - h. Maximum Inlet Pressure: **1 psig (6.9 kPa) OR 2 psig (13.8 kPa) OR 5 psig (34.5 kPa-), as directed.**
- H. Service Meters
- 1. Diaphragm-Type Service Meters: Comply with ANSI B109.1 **OR ANSI B109.2, as directed.**
    - a. Case: Die-cast aluminum.
    - b. Connections: Steel threads.
    - c. Diaphragm: Synthetic fabric.
    - d. Diaphragm Support Bearings: Self-lubricating.
    - e. Compensation: Continuous temperature and pressure, **as directed.**
    - f. Meter Index: Cubic feet **OR Liters OR Cubic feet and liters, as directed.**
    - g. Meter Case and Index: Tamper resistant.
    - h. Remote meter reader compatible.
    - i. Maximum Inlet Pressure: **100 psig (690 kPa).**
    - j. Pressure Loss: Maximum **0.5-inch wg (124 Pa) OR 2.0-inch wg (498 Pa), as directed.**
    - k. Accuracy: Maximum plus or minus 1.0 percent.
  - 2. Rotary-Type Service Meters: Comply with ANSI B109.3.
    - a. Case: Extruded aluminum.
    - b. Connection: Flange.
    - c. Impellers: Polished aluminum.
    - d. Rotor Bearings: Self-lubricating.
    - e. Compensation: Continuous temperature and pressure, **as directed.**
    - f. Meter Index: Cubic feet **OR Liters OR Cubic feet and liters, as directed.**
    - g. Tamper resistant.
    - h. Remote meter reader compatible.
    - i. Maximum Inlet Pressure: **100 psig (690 kPa).**
    - j. Accuracy: Maximum plus or minus 2.0 percent.
  - 3. Turbine Meters: Comply with ASME MFC-4M.
    - a. Housing: Cast iron or welded steel.
    - b. Connection Threads or Flanges: Steel.

- c. Turbine: Aluminum or plastic.
- d. Turbine Bearings: Self-lubricating.
- e. Compensation: Continuous temperature and pressure, **as directed**.
- f. Meter Index: Cubic feet **OR** Liters **OR** Cubic feet and liters, **as directed**.
- g. Tamper resistant.
- h. Remote meter reader compatible.
- i. Maximum Inlet Pressure: **100 psig (690 kPa)**.
- j. Accuracy: Maximum plus or minus 2.0 percent.
- 4. Service-Meter Bars:
  - a. Malleable- or cast-iron frame for supporting service meter.
  - b. Include offset swivel pipes, meter nuts with o-ring seal, and factory- or field-installed dielectric unions.
  - c. Omit meter offset swivel pipes if service-meter bar dimensions match service-meter connections.
- 5. Service-Meter Bypass Fittings:
  - a. Ferrous, tee, pipe fitting with capped side inlet for temporary LPG supply.
  - b. Integral ball-check bypass valve.
- I. Dielectric Fittings
  - 1. Dielectric Unions:
    - a. Minimum Operating-Pressure Rating: **150 psig (1034 kPa)**.
    - b. Combination fitting of copper alloy and ferrous materials.
    - c. Insulating materials suitable for LPG.
    - d. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
  - 2. Dielectric Flanges:
    - a. Minimum Operating-Pressure Rating: **150 psig (1034 kPa)**.
    - b. Combination fitting of copper alloy and ferrous materials.
    - c. Insulating materials suitable for LPG.
    - d. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
  - 3. Dielectric-Flange Kits:
    - a. Minimum Operating-Pressure Rating: **150 psig (1034 kPa)**.
    - b. Companion-flange assembly for field assembly.
    - c. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
    - d. Insulating materials suitable for LPG.
    - e. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.
- J. Storage Containers
  - 1. Description: Factory fabricated, complying with requirements in NFPA 58 and ASME Boiler and Pressure Vessel Code and bearing the ASME label. Tanks shall be rated for **250-psig (1723-kPa)** minimum working pressure.
    - a. Liquid outlet and vapor inlet and outlet connections shall have shutoff valves with excess-flow safety shutoff valves and bypass and back-pressure check valves with smaller than **0.039-inch (1-mm)** drill-size hole to equalize pressure. Liquid-fill connection shall have backflow check valve.
      - 1) Connections: Color-code and tag valves to indicate type.
        - a) Liquid fill and outlet, red.
        - b) Vapor inlet and outlet, yellow.
    - b. Level gage shall indicate current level of liquid in the container. Gages shall also indicate storage container contents; e.g., "Butane," "50-50 LPG Mix," or "Propane."
    - c. Pressure relief valves, type and number as required by NFPA 58, connected to vapor space and having discharge piping same size as relief-valve outlet and long enough to extend at least **84 inches (2130 mm)** directly overhead. Identify relief valves as follows:



- 1) Discharge pressure in **psig (kPa)**.
- 2) Rate of discharge for standard air in **cfm (L/s)**.
- 3) Manufacturer's name.
- 4) Catalog or model number.
- d. Container pressure gage.
- e. For outdoor installation, exposed metal surfaces mechanically cleaned, primed, and painted for resistance to corrosion.
- f. Ladders for access to valves more than **72 inches (1830 mm)** aboveground.
- g. Stainless-Steel Nameplate: Attach to aboveground storage container or to adjacent structure for underground storage container.
  - 1) Name and address of supplier or trade name of container.
  - 2) Water capacity in gallons and liters.
  - 3) Design pressure in psig (kPa).
  - 4) Statement, "This container shall not contain a product having a vapor pressure in excess of **<Insert maximum pressure in psig (kPa) at 100 deg F (37.8 deg C)>**."
  - 5) Outside surface area in sq. ft. (sq. m).
  - 6) Year of manufacture.
  - 7) Shell thickness in inches (mm).
  - 8) Overall length in feet (m).
  - 9) OD in feet (m).
  - 10) Manufacturer's serial number.
  - 11) ASME Code label.
- h. Felt support pads and two concrete or painted-steel saddles per storage container. Corrosion protection required at container-to-felt contact.
- i. Tie straps for each saddle.
- j. Straps and anchors for tie-down slab.
- k. Asphalt-based coating for corrosion protection.
- l. Container connections and valves protected in manway at top of storage container.
- m. Manway equipped with ventilation louvers.

#### K. Transport Truck Unloading Facility

1. Description: Comply with requirements in NFPA 58.
  - a. Support structure consisting of a minimum **6-inch (150-mm)** steel channel or **6-by-4-inch (150-by-100-mm)** rectangular steel tubing, a minimum of **36 inches (914 mm)** above and below grade.
  - b. Liquid-fill and vapor-return, quick-disconnect fittings.
  - c. Liquid and vapor shutoff valves with hydrostatic relief valves mounted between the quick-disconnect fittings and shutoff valves.
  - d. Excess-flow safety shutoff valve in vapor-return line.
  - e. Backflow check valve in liquid-fill line.
  - f. Remote emergency shutoff valve station with underground cable to the vapor emergency shutoff valve.

#### L. Pumps

1. Description: Factory-assembled and -tested, duplex, positive-displacement, belt drive.
2. Pump Construction:
  - a. Casing: Ductile-iron casing with threaded gage tappings at inlet and outlet.
  - b. Internal Pressure Relief Valve: For pump protection in addition to the external pressure relief valves.
  - c. Impeller: Carbon or composite vane in cast-iron rotor.
  - d. Pump Shaft: Carbon steel.
  - e. Seal: Mechanical with Buna-N o-ring.
  - f. Pump Bearings: Ball bearings with grease fittings.
  - g. Baseplate: Bent carbon-steel channel or structural channel.



3. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
    - c. Motor Speeds: Single.
    - d. Bearings: Permanently lubricated **OR** Grease-lubricated, **as directed**, ball bearings.
    - e. Class I, Division 1, Group D requirements per NFPA 70.
  4. Factory-Installed Piping and Specialties:
    - a. Pipe: ASTM A 53/A 53M, Type E or S, Grade B; Schedule 40 black steel with welded fittings and joints or Schedule 80 for threaded malleable-iron fittings and joints.
    - b. Piping Specialties for Each Pump:
      - 1) Bypass valve.
      - 2) Isolation valves.
      - 3) Unions for each connection.
      - 4) Check valve.
      - 5) Basket strainer.
      - 6) Pressure gages for suction and discharge connections.
      - 7) Hydrostatic relief valve.
      - 8) Pilot-operated, pressure-regulating valve.
  5. Braided-jacket flexible connectors for suction and discharge connections.
  6. Pump and Piping Finish: For outdoor installation, exposed metal surfaces mechanically cleaned, primed, and painted for resistance to corrosion.
  7. Controls:
    - a. Explosion-proof controls enclosure.
    - b. Magnetic starter package with automatic alternator.
    - c. Pressure-activated start and stop.
    - d. Lag pump starts if lead pump fails.
    - e. Audible and visual indication of pump failure.
- M. Vaporizers
1. Description: Factory-fabricated, -assembled, and -tested vaporizer with heat exchanger sealed pressure-tight, built on a steel base; including insulated jacket, flue-gas vent, liquid fuel supply and vapor connections, and controls. Assembly shall be FMG labeled and comply with NFPA 58 and NFPA 70.
  2. Fabricate base and attachment to vaporizers with reinforcement strong enough to resist vaporizer movement during a seismic event when steel base is anchored to a concrete base.
  3. Casing:
    - a. Mineral-fiber insulation, a minimum of **2 inches (50 mm)** thick, surrounding the heat exchanger.
    - b. Integral one-piece skid with forklift access holes.
    - c. Lifting lugs on top of vaporizer.
    - d. Flue rain cap and bird screen.
    - e. Sheet metal jacket with screw-fastened closures and baked-enamel **OR** powder-coat, **as directed**, protective finish.
    - f. Mounting base to secure boiler to concrete base.
    - g. Control Compartment Enclosure: NEMA 250, Type 4, enclosure housing control panels for LPG-fired vaporizers. Explosion-proof control compartment construction required for electric vaporizers.
  4. LPG Liquid and Vapor Circuit Specialties:
    - a. Y-type strainer with drain valve at inlet.
    - b. Vaporizer coil safety pressure relief valve.
    - c. Vaporizer coil blowdown valve.
    - d. Vapor outlet isolation valve.

- e. Pressure gages, a minimum of **2-1/2 inches (63 mm)** in diameter, at liquid inlet and vapor discharge. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
  - f. Inlet safety solenoid valve to close with off-normal operation alarm.
  - g. Backflow check valve in bypass around inlet safety solenoid valve.
  - h. Liquid carryover or float-type safety shutoff switch.
  - i. LPG Vapor Filter: Steel shell designed and manufactured per ASME Boiler and Pressure Vessel Code, Section VIII, Division 1; factory mounted on vaporizer discharge. Shells larger than **5 inches (125 mm)** shall be ASME "U" stamped. Fill with stainless-steel, woven-mesh coalescing element to remove 99 percent of particles larger than 10 microns. **250-psig (1723-kPa)** minimum working pressure. Finish with corrosion-resistant coating for an exterior application. Include factory-mounted and -piped, differential pressure gage with gage cocks in and out, and minimum **NPS 3/4 (DN 20)** full-port, ball-type drain valve.
5. Direct-Type, Direct-Fired Heat Exchanger:
- a. Description: ASME-rated and -stamped, LPG, vaporizer coil contained in an enclosure insulated with at least **2-inch- (50-mm-)** thick, mineral-fiber board enclosure with a burner.
  - b. Burner Tubes and Orifices: Stainless steel.
    - 1) Gas Train: Control devices and burner control sequence shall be FMG labeled. Include shutoff valve, high- and low-pressure safety switches, pressure regulator, and main- and pilot-control valves.
    - 2) Pilot: Standing pilot with 100 percent main-valve and pilot safety shutoff.
  - c. Burner Operating Controls:
    - 1) Controls shall maintain safe operating conditions. Mechanical burner safety controls limit operation of the burner.
    - 2) High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design pressure.
    - 3) Operating Vapor-Pressure Control: Factory piped and mounted to control burner.
6. Indirect-Type, Direct-Fired Heat Exchanger:
- a. Description: ASME-rated and -stamped, LPG, vaporizer vessel with a replaceable, immersion-type, electric heating element.
  - b. Heating Element Operating Controls:
    - 1) Operating controls shall maintain safe operating conditions. Safety controls limit operation of the element. Microprocessor-based control system integrates safety and operating controls, **as directed**.
    - 2) Operating Vapor-Pressure Control: Factory wired and mounted to control heating element.
    - 3) High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design pressure.
    - 4) Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
    - 5) Control Transformer: 115-V maximum control voltage.
7. Direct-Type, Water-Bath Heat Exchanger:
- a. Description: Straight, steel fire tubes welded into steel headers with ASME-rated and -stamped, helical, LPG, vaporizer coil submerged in water bath. Include the following:
    - 1) Water bath filled with water/glycol solution designed to prevent freezing at **minus 30 deg F (minus 34 deg C)**.
    - 2) Water-bath, high- and low-level sight glasses.
    - 3) Low-water cutoff to stop burner and annunciate alarm.
    - 4) Water/glycol fill and vent fitting.
    - 5) Minimum **NPS 3/4 (DN 20)** hose-end drain valves.
    - 6) Operating high- and low-limit aquastat controllers.
    - 7) Water-bath temperature gage; a minimum of **2-1/2 inches (63 mm)** in diameter. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
  - b. Burner Tubes and Orifices: Stainless steel.



- 1) Gas Train: Control devices and burner modulation control sequence shall be FMG labeled. Include shutoff valve, high- and low-pressure safety switches, pressure regulator, and main- and pilot-control valves.
  - 2) Pilot: Intermittent-electric-spark **OR** Hot-surface, **as directed**, pilot ignition with 100 percent main-valve and pilot safety shutoff with electronic supervision of burner flame.
  - c. Burner Operating Controls:
    - 1) Operating controls shall maintain safe operating conditions. Safety controls limit operation of the burner. Microprocessor-based control system integrates safety and operating controls, **as directed**.
    - 2) Operating Water-Bath Temperature Control: Factory wired and mounted to control burner.
    - 3) High-Temperature and High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design temperature or vapor pressure.
    - 4) Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
    - 5) Control Transformer: 115-V maximum control voltage.
  8. Indirect-Type, Water-Bath Heat Exchanger:
    - a. Description: Immersion-type, electric heating element with ASME-rated and -stamped, helical, LPG, vaporizer coil submerged in water bath. Include the following:
      - 1) Water bath filled with water/glycol solution designed to prevent freezing at **minus 30 deg F (minus 34 deg C)**.
      - 2) Water-bath, high- and low-level sight glasses.
      - 3) Low-water cutoff to stop electric heater and annunciate alarm.
      - 4) Water/glycol fill and vent fitting.
      - 5) Minimum **NPS 3/4 (DN 20)** hose-end drain valves.
      - 6) Operating high- and low-limit aquastat controllers.
      - 7) Water-bath temperature gage; a minimum of **2-1/2 inches (63 mm)** in diameter. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
    - b. Electric Heater Operating Controls:
      - 1) Controls shall maintain safe operating conditions. Safety controls limit operation of the electric element. Microprocessor-based control system integrates safety and operating controls, **as directed**.
      - 2) Operating Water-Bath Temperature Control: Factory wired and mounted to control burner.
      - 3) High-Temperature and High-Pressure Cutoff: Manual reset stops burner if operating conditions rise above maximum design temperature or pressure.
      - 4) Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
      - 5) Control Transformer: 115-V maximum control voltage.
  9. Building Management System Interface: Factory-installed hardware and software to enable building management system to monitor and control set points and display vaporizer status and alarms.
- N. Air Mixers
1. Description: Factory-fabricated, -assembled, -calibrated, and -tested, blower-assisted, **as directed**, air mixer with surge tank, built on a steel base; including vapor supply and discharge connections, and controls. Assembly shall be FMG labeled and comply with NFPA 58 and NFPA 70.
  2. Fabricate base and attachment to mixers with reinforcement strong enough to resist air mixer movement during a seismic event when steel base is anchored to a concrete base.
  3. Mounting Skid, Panels, and Surge Tank:
    - a. Integral one-piece skid with forklift access holes.
    - b. Lifting lugs on top of air mixer.
    - c. Baked-enamel **OR** Powder-coat, **as directed**, protective finish.

- d. Mounting base to secure boiler to concrete base.
- e. Control Compartment Enclosure: NEMA 250, Type 4, enclosure housing control panels.
- f. ASME-stamped surge tank with venturi, isolation valves, excess-flow safeties, and safety relief valves.
- 4. Blower: Positive-displacement, rotary-lobe type.
  - a. Motor: Single speed, with permanently lubricated **OR** grease-lubricated, **as directed**, ball bearings. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- 5. LPG Circuit Specialties:
  - a. Venturi solenoid valves.
  - b. Venturi nozzles, minimum of 3, for minimum of 10:1 turndown capacity.
  - c. Venturi silencers.
  - d. Mist filter and strainer with pressure differential gage, and blowdown ball valve.
  - e. Inlet and outlet isolation valves.
  - f. Pressure gages, a minimum of **2-1/2 inches (63 mm)** in diameter, at inlet and discharge. Gages shall have operating-temperature ranges so normal operating range is at approximately 50 percent of full range.
- 6. Air-Mixer Controls:
  - a. Controls shall maintain safe operating conditions. The following safety controls limit the operation of the air mixer. All safety controls are manual reset.
    - 1) Low-inlet-vapor pressure.
    - 2) High- or low-discharge pressure.
  - b. Alarm Bell and Rotary Beacon: Factory mounted on control panel with silence switch; shall sound alarm for out-of-normal conditions.
  - c. Control Transformer: 115-V maximum control voltage.
- 7. Mount on common skid with vaporizer.
- O. Sleeves
  - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
  - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- P. Mechanical Sleeve Seals
  - 1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
    - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
    - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**.
    - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.
- Q. Escutcheons
  - 1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.
  - 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn brass with polished chrome-plated finish.
  - 3. One-Piece, Cast-Brass Escutcheons: With set screw.
    - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
  - 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
    - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
  - 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
  - 6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.

7. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.
8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

R. Grout

1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
  - a. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
  - b. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.
  - c. Packaging: Premixed and factory packaged.

S. Labeling And Identifying

1. Detectable Warning Tape: Acid- and alkali-resistant PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored yellow.

### 1.3 EXECUTION

A. Earthwork

1. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Preparation

1. Close equipment shutoff valves before turning off LPG to premises or piping section.
2. Inspect LPG piping according to NFPA 58 and NFPA 54 **OR** the International Fuel Gas Code, **as directed**, to determine that LPG utilization devices are turned off in piping section affected.
3. Comply with NFPA 58 and NFPA 54 **OR** the International Fuel Gas Code, **as directed**, requirements for prevention of accidental ignition.

C. Outdoor Piping Installation

1. Comply with NFPA 58 and NFPA 54 **OR** the International Fuel Gas Code, **as directed**, requirements for installation and purging of LPG piping.
2. Install underground, LPG piping buried at least 36 inches (900 mm) below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
  - a. If LPG piping is installed less than 36 inches (914 mm) below finished grade, install it in containment conduit.
3. Install underground, PE, LPG piping according to ASTM D 2774.
4. Steel Piping with Protective Coating:
  - a. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
  - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.

**OR**

Replace pipe having damaged PE coating with new pipe.
5. Copper Tubing with Protective Coating:
  - a. Apply joint cover kits over tubing to cover, seal, and protect joints.
  - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
6. Install fittings for changes in direction and branch connections.
7. Joints for connection to inlets and outlets on vaporizers, air mixers, regulators, and valves may be flanged or threaded to match the equipment.
8. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.



- a. Install steel pipe for sleeves smaller than **6 inches (150 mm)** in diameter.
- b. Install cast-iron "wall pipes" for sleeves **6 inches (150 mm)** and larger in diameter.
9. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
10. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
11. Install pressure gage downstream **OR** upstream and downstream, **as directed**, from each service regulator. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".

#### D. Indoor Piping Installation

1. Comply with NFPA 54 **OR** the International Fuel Gas Code, **as directed**, for installation and purging of LPG piping.
2. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
3. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
5. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
7. Locate valves for easy access.
8. Install LPG piping at uniform grade of 2 percent down toward drip and sediment traps.
9. Install piping free of sags and bends.
10. Install fittings for changes in direction and branch connections.
11. Install escutcheons for penetrations of interior walls, ceilings, and floors.
  - a. New Piping:
    - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    - 2) Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.  
**OR**  
Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
    - 3) Piping at Ceiling Penetrations in Finished Spaces: One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.  
**OR**  
Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
    - 4) Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.  
**OR**  
Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
    - 5) Piping in Equipment Rooms: One-piece, cast-brass type.  
**OR**  
Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.

- 6) Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- b. Existing Piping:
  - 1) Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.  
**OR**  
Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
  - 2) Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.  
**OR**  
Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
  - 3) Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.  
**OR**  
Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
  - 4) Piping in Equipment Rooms: Split-casting, cast-brass type.  
**OR**  
Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
  - 5) Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
12. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping" for materials.
13. Verify final equipment locations for roughing-in.
14. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
15. Drips and Sediment Traps: Install drips at points where condensate may collect, including service-meter outlets. Locate where readily accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
  - a. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than **3 inches (75 mm)** long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
16. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
17. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
18. Concealed Location Installations: Except as specified below, install concealed LPG piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
  - a. Above Accessible Ceilings: LPG piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.
  - b. In Floors: Install LPG piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of **1-1/2 inches (38 mm)** of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
  - c. In Floor Channels: Install LPG piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
  - d. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
    - 1) Exception: Tubing passing through partitions or walls does not require striker barriers.



- e. Prohibited Locations:
  - 1) Do not install LPG piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
  - 2) Do not install LPG piping in solid walls or partitions.
- 19. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- 20. Connect branch piping from top or side of horizontal piping.
- 21. Install unions in pipes **NPS 2 (DN 50)** and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- 22. Do not use LPG piping as grounding electrode.
- 23. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- 24. Install pressure gage downstream **OR** upstream and downstream, **as directed**, from each line regulator. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".
- E. Service-Meter Assembly Installation
  - 1. Install service-meter assemblies aboveground, on concrete bases, **as directed**.
  - 2. Install metal shutoff valves upstream from service regulators. Shutoff valves are not required at second regulators if two regulators are installed in series.
  - 3. Install strainer on inlet of service-pressure regulator and meter set.
  - 4. Install service regulators mounted outside with vent outlet horizontal or facing down. Install screen in vent outlet if not integral with service regulator.
  - 5. Install metal shutoff valves upstream from service meters. Install dielectric fittings downstream from service meters.
  - 6. Install service meters downstream from pressure regulators.
  - 7. Install metal bollards to protect meter assemblies. Comply with requirements in Division 05 Section "Metal Fabrications" for pipe bollards.
- F. Valve Installation
  - 1. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
  - 2. Install underground valves with valve boxes.
  - 3. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
  - 4. Install earthquake valves aboveground outside buildings according to listing.
  - 5. Install anode for metallic valves in underground PE piping.
- G. Piping Joint Construction
  - 1. Ream ends of pipes and tubes and remove burrs.
  - 2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
  - 3. Threaded Joints:
    - a. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
    - b. Cut threads full and clean using sharp dies.
    - c. Ream threaded pipe ends to remove burrs and restore full ID of pipe.
    - d. Apply appropriate tape or thread compound to external pipe threads unless dryseal threading is specified.
    - e. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
  - 4. Welded Joints:
    - a. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
    - b. Bevel plain ends of steel pipe.
    - c. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Ch. 22, "Pipe and Tube."
  6. Flanged Joints: Install gasket material, size, type, and thickness appropriate for LPG service. Install gasket concentrically positioned.
  7. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.
  8. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
    - a. Plain-End Pipe and Fittings: Use butt fusion.
    - b. Plain-End Pipe and Socket Fittings: Use socket fusion.
- H. Hanger And Support Installation
1. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  2. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
  3. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
    - a. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches (2438 mm); minimum rod size, 3/8 inch (10 mm).
    - b. NPS 1-1/4 (DN 32): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
    - c. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches (2743 mm); minimum rod size, 3/8 inch (10 mm).
    - d. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet (3 m); minimum rod size, 1/2 inch (13 mm).
    - e. NPS 4 (DN 100) and Larger: Maximum span, 10 feet (3 m); minimum rod size, 5/8 inch (16 mm).
  4. Install hangers for horizontal, drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
    - a. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
    - b. NPS 1/2 and NPS 5/8 (DN 15 and DN 18): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
    - c. NPS 3/4 and NPS 7/8 (DN 20 and DN 22): Maximum span, 84 inches (2134 mm); minimum rod size, 3/8 inch (10 mm).
    - d. NPS 1 (DN 25): Maximum span, 96 inches (2440 mm); minimum rod size, 3/8 inch (10 mm).
  5. Install hangers for horizontal, corrugated stainless-steel tubing with the following maximum spacing and minimum rod sizes:
    - a. NPS 3/8 (DN 10): Maximum span, 48 inches (1220 mm); minimum rod size, 3/8 inch (10 mm).
    - b. NPS 1/2 (DN 15): Maximum span, 72 inches (1830 mm); minimum rod size, 3/8 inch (10 mm).
    - c. NPS 3/4 (DN 20) and Larger: Maximum span, 96 inches (2440 mm); minimum rod, 3/8 inch (10 mm).
- I. Connections
1. Connect to utility's gas main according to utility's procedures and requirements.
  2. Install LPG piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
  3. Install piping adjacent to appliances to allow service and maintenance of appliances.
  4. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches (1830 mm) of each gas-fired appliances and equipment. Install union between valve and appliances or equipment.





5. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.
- J. Transport Truck Unloading Facility
1. Install transport truck unloading in a cast-in-place concrete base, **48 inches (1220 mm)** square by **36 inches (914 mm)** deep. Set top of concrete base at least **6 inches (150 mm)** above finished grade.
  2. Install remote emergency shutoff station with cable release in an accessible location, a minimum of **25 feet (7.6 m)** and a maximum of **100 feet (30 m)** away from transport truck unloading.
  3. Install at least two **6-inch- (150-mm-)** diameter metal bollards set in and filled with concrete on both sides of transport truck unloading. Bollard length shall be at least **48 inches (1220 mm)** above and below grade, with concrete encasement a minimum of **12 inches (305 mm)** in diameter.
- K. Storage Container Installation
1. Fill storage container to at least 80 percent capacity with butane **OR** propane, **as directed**.
  2. Install piping connections with swing joints or flexible connectors to allow for storage container settlement and for thermal expansion and contraction.
  3. Ground containers according to NFPA 780. Grounding is specified in Division 26 Section "Lightning Protection For Structures".
  4. Set storage containers in felt pads on concrete or steel saddles. Install corrosion protection at container-to-felt contact.
  5. Install tie-downs over storage containers on saddles with proper tension.
  6. Set concrete saddles on dowels set in concrete base. Anchor steel saddles to concrete base.
  7. Set storage container on concrete ballast base large enough to offset buoyancy of empty storage container immersed in water.
  8. Install tie-down straps over container anchored in ballast base and repair damaged coating.
  9. Backfill with a minimum coverage for underground or mounded storage containers according to NFPA 58.
  10. Backfill with pea gravel as required in Division 31 Section "Earth Moving".
  11. Install cathodic protection for storage container. Cathodic protection is specified in Division 26 Section "Cathodic Protection".
- L. Pump Installation
1. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
  2. Set pumps on and anchored to concrete base.
  3. Install suction piping with minimum fittings and change of direction.
  4. Connect liquid suction to container, supply to vaporizer, and return line to container.
- M. Vaporizer Installation
1. Install vaporizer with access space for periodic maintenance.
  2. Set vaporizers on and anchor to concrete base.
  3. Connect liquid line from pump set, and vapor supply to distribution piping.
  4. Install backup connection from vapor space of container to inlet of pressure-regulating valve at vaporizer discharge to bypass the vaporizer during maintenance. Install shutoff valves to change source from vaporizer to storage container.
- N. Air Mixer With Vaporizer Installation
1. Install air mixer with vaporizer with access space for periodic maintenance.
  2. Set air mixer with vaporizer on and anchor to concrete base.
  3. Connect liquid line from pump set, and mixed gas supply to distribution piping.
  4. Install backup connection from vapor space of container to inlet of pressure-regulating valve at vaporizer discharge to bypass vaporizer during maintenance. Install shutoff valves to change source from vaporizer to storage container.

5. Replace filters at Final Completion if air mixer was operated during construction.
- O. Labeling And Identifying
  1. Comply with requirements in Division 23 Section "Identification For Hvac Piping And Equipment" for piping and valve identification.  
**OR**  
Install detectable warning tape directly above gas piping, **12 inches (305 mm)** below finished grade, except **6 inches (150 mm)** below subgrade under pavements and slabs.
- P. Painting
  1. Comply with requirements in Division 07 for painting interior and exterior LPG piping.
  2. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components with factory-applied paint or protective coating.
    - a. Alkyd System: MPI EXT 5.1D.
      - 1) Prime Coat: Alkyd anticorrosive metal primer.
      - 2) Intermediate Coat (for a Premium Grade system): Exterior alkyd enamel matching topcoat.
      - 3) Topcoat: Exterior alkyd enamel (flat) **OR** (semigloss) **OR** (gloss), **as directed**.
      - 4) Color: Gray, **unless directed otherwise**.
    3. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components with factory-applied paint or protective coating.
      - a. Latex Over Alkyd Primer System: MPI INT 5.1Q.
        - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
        - 2) Intermediate Coat (for a Premium Grade system): Interior latex matching topcoat.
        - 3) Topcoat: Interior latex (flat) **OR** (low sheen) **OR** (eggshell) **OR** (satin) **OR** (semigloss) **OR** (gloss), **as directed**.
        - 4) Color: Gray, **unless directed otherwise**.
      - b. Alkyd System: MPI INT 5.1E.
        - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
        - 2) Intermediate Coat (for a Premium Grade system): Interior alkyd matching topcoat.
        - 3) Topcoat: Interior alkyd (flat) **OR** (eggshell) **OR** (semigloss) **OR** (gloss), **as directed**.
        - 4) Color: Gray, **unless directed otherwise**.
    4. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.
  - Q. Concrete Bases
    1. Concrete Bases: Anchor equipment to concrete base according to seismic codes at Project.
      - a. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit.
      - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (451-mm)** centers around the full perimeter of the base.
      - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
      - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
      - f. Use **3000-psi (20.7-MPa)**, **unless directed otherwise**, 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
  - R. Field Quality Control
    1. Perform tests and inspections.
    2. Tests and Inspections:

- a. Test, inspect, and purge LPG according to NFPA 58 and NFPA 54 **OR** the International Fuel Gas Code, **as directed**, and requirements of authorities having jurisdiction.
3. LPG piping will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

S. Outdoor Piping Schedule

1. Underground LPG liquid piping shall be one of the following:
  - a. Schedule 40 steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
  - b. Annealed **OR** Drawn, **as directed**, -temper copper tube, **Type K (Type A) OR Type L (Type B)**, **as directed**, with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
2. Aboveground LPG liquid piping shall be one of the following:
  - a. **NPS 2 (DN 50)** and Smaller: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe, malleable-iron threaded fittings and threaded and seal welded, **as directed**, joints. Coat pipe and fittings with protective coating for steel piping.
  - b. **NPS 2-1/2 (DN 65)** and Larger: Schedule 40, steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
  - c. Annealed **OR** Drawn, **as directed**, -temper copper tube, **Type L (Type B)**, with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
3. Underground LPG vapor piping shall be one of the following:
  - a. PE pipe and fittings joined by heat-fusion, or mechanical couplings; service-line risers with tracer wire terminated in an accessible location.
  - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
  - c. Annealed **OR** Drawn, **as directed**, -temper copper tube, **Type L (Type B)** with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
4. Aboveground LPG vapor piping shall be one of the following:
  - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
  - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints, or mechanical couplings.
  - c. Annealed **OR** Drawn, **as directed**, -temper copper tube, **Type L (Type B)**, with wrought-copper fittings and brazed joints. Coat pipe and fittings with protective coating for copper tubing.
5. Branch Piping in Cast-in-Place Concrete to Single Appliance: Annealed-temper copper, with wrought-copper fittings and brazed **OR** flared, **as directed**, joints. Install piping embedded in concrete with no joints in concrete.
6. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

T. Indoor Piping Schedule For System Pressures Less Than **0.5 psig (3.45 kPa)**

1. Aboveground, branch piping **NPS 1 (DN 25)** and smaller shall be one of the following:
  - a. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
  - b. Annealed-temper, tin-lined copper tube with flared joints and fittings.
  - c. Annealed-temper copper tube with wrought-copper fittings and brazed **OR** flared, **as directed**, joints.
  - d. Aluminum tube with flared fittings and joints.
  - e. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
2. Aboveground, distribution piping shall be one of the following:
  - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
  - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints.

- c. Drawn-temper copper tube, **Type L (Type B)** with wrought-copper fittings and brazed joints.
  3. Underground, below building, piping shall be one of the following:
    - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
    - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints.
  4. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
  5. Containment Conduit Vent Piping: Schedule 40, steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- U. Indoor Piping Schedule For System Pressures More Than **0.5 psig (3.45 kPa)** And Less Than **5 psig (34.5 kPa)**
  1. Aboveground, branch piping **NPS 1 (DN 25)** and smaller shall be one of the following:
    - a. Corrugated stainless-steel tubing with mechanical fittings having socket or threaded ends to match adjacent piping.
    - b. Annealed-temper, tin-lined copper tube with flared joints and fittings.
    - c. Annealed-temper copper tube, **Type L (Type B)** with wrought-copper fittings and brazed **OR** flared, **as directed**, joints.
    - d. Aluminum tube with flared fittings and joints.
    - e. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
  2. Aboveground, distribution piping shall be one of the following:
    - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
    - b. Schedule 40, steel pipe with steel welding fittings and welded joints.
    - c. Drawn-temper copper tube, **Type L (Type B)** **OR** Type G, **as directed**, with wrought-copper fittings and brazed joints.
  3. Underground, below building, piping shall be one of the following:
    - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
    - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints.
  4. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat underground pipe and fittings with protective coating for steel piping.
  5. Containment Conduit Vent Piping: Schedule 40, steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- V. Indoor Piping Schedule For System Pressures More Than **5 psig (34.5 kPa)**
  1. Aboveground Piping: Maximum operating pressure more than **5 psig (34.5 kPa)**.
  2. Aboveground, Branch Piping: Schedule 40, steel pipe with steel welding fittings and welded joints.
  3. Aboveground, distribution piping shall be one of the following:
    - a. Schedule 40, steel pipe with steel welding fittings and welded joints.
    - b. Drawn-temper copper tube, **Type L (Type B)** **OR** Type G, **as directed**, with wrought-copper fittings and brazed joints.
  4. Underground, below building, piping shall be one of the following:
    - a. Schedule 40, steel pipe with malleable-iron fittings and threaded joints.
    - b. Schedule 40, steel pipe with wrought-steel fittings and welded joints.
  5. Containment Conduit: Schedule 40, steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
  6. Containment Conduit Vent Piping: Schedule 40, steel pipe with malleable-iron fittings and threaded or wrought-steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.
- W. Underground Manual Gas Shutoff Valve Schedule
  1. Connections to Existing Gas Piping: Use valve and fitting assemblies made for tapping utility's gas mains and listed by an NRTL.
  2. Underground Vapor Piping:
    - a. PE valves.

- b. **NPS 2 (DN 50)** and Smaller: Bronze, lubricated **OR** nonlubricated, **as directed**, plug valves.
- c. **NPS 2-1/2 (DN 65)** and Larger: Cast-iron, lubricated **OR** nonlubricated, **as directed**, plug valves.

X. Aboveground Manual Gas Shutoff Valve Schedule

- 1. Aboveground Liquid Piping:
  - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
- 2. Valves for pipe **NPS 2 (DN 50)** and smaller at service meter shall be one of the following:
  - a. One-piece, bronze ball valve with bronze trim.
  - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - c. Bronze plug valve.
- 3. Valves for pipe **NPS 2-1/2 (DN 65)** and larger at service meter shall be one of the following:
  - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - b. Bronze plug valve.
  - c. Cast-iron, nonlubricated plug valve.
- 4. Distribution piping valves for pipe **NPS 2 (DN 50)** and smaller shall be one of the following:
  - a. One-piece, bronze ball valve with bronze trim.
  - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - c. Bronze plug valve.
- 5. Distribution piping valves for pipe **NPS 2-1/2 (DN 65)** and larger shall be one of the following:
  - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - b. Bronze plug valve.
  - c. Cast-iron, nonlubricated **OR** lubricated, **as directed**, plug valve.
- 6. Valves in branch piping for single appliance shall be one of the following:
  - a. One-piece, bronze ball valve with bronze trim.
  - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - c. Bronze plug valve.

END OF SECTION 23 11 23 00c

Task	Specification	Specification Description
23 11 23 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 11 23 00	22 11 23 23	Water Supply Wells
23 11 23 00	22 05 76 00	Sanitary Sewerage
23 11 23 00	07 63 00 00	Common Work Results for Fire Suppression
23 11 23 00	07 63 00 00a	Common Work Results for Plumbing
23 11 23 00	07 63 00 00b	Common Work Results for HVAC
23 11 26 00	23 11 23 00	Relief Wells
23 11 26 00	22 05 76 00	Sanitary Sewerage
23 11 26 00	22 12 23 26	Underground Storage Tanks
23 11 26 00	07 63 00 00	Common Work Results for Fire Suppression
23 11 26 00	07 63 00 00a	Common Work Results for Plumbing
23 11 26 00	07 63 00 00b	Common Work Results for HVAC
23 11 26 00	22 11 16 00a	Sanitary Waste And Vent Piping
23 12 13 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 12 23 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 13 13 13	21 05 23 00	Piped Utilities Basic Materials And Methods
23 13 13 13	22 12 23 26	Underground Storage Tanks
23 13 13 23	21 05 23 00	Piped Utilities Basic Materials And Methods
23 13 13 23	22 12 23 26	Underground Storage Tanks
23 13 23 16	21 05 23 00	Piped Utilities Basic Materials And Methods
23 13 23 19	21 05 23 00	Piped Utilities Basic Materials And Methods
23 13 23 26	21 05 23 00	Piped Utilities Basic Materials And Methods
23 13 33 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 13 33 00	22 12 23 26	Underground Storage Tanks

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## SECTION 23 21 13 23 - FACILITY FUEL-OIL PIPING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for facility fuel-oil piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes fuel-oil, fuel-oil and diesel-fuel-oil, and diesel-fuel-oil distribution systems and the following:
  - a. Pipes, tubes, and fittings.
  - b. Piping and tubing joining materials.
  - c. Piping specialties.
  - d. Valves.
  - e. Vertical, steel, fuel-oil ASTs.
  - f. Horizontal, steel, fuel-oil ASTs.
  - g. Containment-dike, steel, fuel-oil ASTs.
  - h. Insulated, steel, fuel-oil ASTs.
  - i. Concrete-vaulted, steel, fuel-oil ASTs.
  - j. Steel, fuel-oil USTs with STI-P3.
  - k. Composite, steel, fuel-oil USTs.
  - l. Jacketed, steel, fuel-oil USTs.
  - m. FRP fuel-oil USTs.
  - n. Fuel-oil AST accessories.
  - o. Fuel-oil UST accessories.
  - p. Fuel-oil storage tank piping specialties.
  - q. Fuel-oil storage tank pumps.
  - r. Fuel-transfer pumps.
  - s. Fuel maintenance system.
  - t. Liquid-level gage system.
  - u. Leak-detection and monitoring system.
  - v. Mechanical sleeve seals.
  - w. Grout.
  - x. Concrete bases.

#### C. Definitions

1. AST: Aboveground storage tank.
2. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
3. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
4. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
5. FPM: Vinylidene fluoride-hexafluoropropylene copolymer rubber.
6. FRP: Glass-fiber-reinforced plastic.
7. UST: Underground storage tank.

#### D. Performance Requirements

1. Maximum Operating-Pressure Ratings: **3-psig (21-kPa)** fuel-oil supply pressure at oil-fired appliances.

2. Delegated Design: Design restraint and anchors for fuel-oil piping, ASTs, and equipment, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Seismic Performance: Factory-installed support attachments for AST shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event, **as directed**."

E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For facility fuel-oil piping layout. Include plans, piping layout and elevations, sections, and details for fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to building structure. Detail location of anchors, alignment guides, and expansion joints and loops.
3. Delegated-Design Submittal: For fuel-oil piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Detail fabrication and assembly of anchors and seismic restraints.
  - b. Design Calculations: Calculate requirements for selecting seismic restraints.
  - c. Detail fabrication and assembly of pipe anchors, hangers, supports for multiple pipes, and attachments of the same to building structure.
4. Seismic Qualification Certificates: For ASTs, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Brazing certificates.
6. Welding certificates.
7. Field quality-control reports.
8. Operation and Maintenance Data.
9. Warranty: Sample of special warranty.

F. Quality Assurance

1. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
2. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. Comply with ASME B31.9, "Building Services Piping," for fuel-oil piping materials, installation, testing, and inspecting.
6. Comply with requirements of the EPA and of state and local authorities having jurisdiction. Include recording of fuel-oil storage tanks and monitoring of tanks and piping.

G. Delivery, Storage, And Handling

1. Lift and support fuel-oil storage tanks only at designated lifting or supporting points, as shown on Shop Drawings. Do not move or lift tanks unless empty.
2. Deliver pipes and tubes with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

3. Store pipes and tubes with protective PE coating to avoid damaging the coating and to protect from direct sunlight.
4. Store PE pipes and valves protected from direct sunlight.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel-oil storage tanks and flexible, double-containment piping and related equipment that fail in materials or workmanship within specified warranty period.
  - a. Storage Tanks:
    - 1) Failures include, but are not limited to, the following when used for storage of fuel oil at temperatures not exceeding **150 deg F (66 deg C)**:
      - a) Structural failures including cracking, breakup, and collapse.
      - b) Corrosion failure including external and internal corrosion of steel tanks.
    - 2) Warranty Period: 30 years from date of Final Completion.
  - b. Flexible, Double-Containment Piping and Related Equipment:
    - 1) Failures due to defective materials or workmanship for materials installed together, including piping, dispenser sumps, entry boots, and sump mounting adapters.
    - 2) Warranty Period: 10 **OR** 30, **as directed**, years from date of Final Completion.

1.2 PRODUCTS

A. Pipes, Tubes, And Fittings

1. See Part 1.3 piping schedule articles for where pipes, tubes, fittings, and joining materials are applied in various services.
2. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  - a. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
  - b. Wrought-Steel Welding Fittings: ASTM A 234/A 234M, for butt and socket welding.
  - c. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
  - d. Forged-Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
    - 1) Material Group: 1.1.
    - 2) End Connections: Threaded or butt welding to match pipe.
    - 3) Lapped Face: Not permitted underground.
    - 4) Gasket Materials: Asbestos free, ASME B16.20 metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
    - 5) Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.
  - e. Protective Coating for Underground Piping: Factory-applied, three-layer coating of epoxy, adhesive, and PE.
    - 1) Joint Cover Kits: Epoxy paint, adhesive, and heat-shrink PE sleeves.
3. Drawn-Temper Copper Tube: Comply with **ASTM B 88, Type K (ASTM B 88M, Type A) OR ASTM B 88, Type L (ASTM B 88M, Type B), as directed**.
  - a. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
  - b. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
    - 1) Gasket Material: Asbestos free, ASME B16.20, metallic, or ASME B16.21 nonmetallic, gaskets compatible with fuel oil.
    - 2) Bolts and Nuts: ASME B18.2.1, cadmium-plated steel.
4. Annealed-Temper Copper Tube: Comply with **ASTM B 88, Type K (ASTM B 88M, Type A) OR ASTM B 88, Type L (ASTM B 88M, Type B), as directed**.
  - a. Copper Fittings: ASME B16.22, wrought copper, streamlined pattern.
  - b. Flare Fittings: Comply with ASME B16.26 and SAE J513.
    - 1) Copper fittings with long nuts.
    - 2) Metal-to-metal compression seal without gasket.
    - 3) Dryseal threads complying with ASME B1.20.3.

B. Double-Containment Pipe And Fittings

1. Flexible, Double-Containment Piping: Comply with UL 971.
  - a. Pipe Materials: PVDF complying with ASTM D 3222 for carrier pipe with mechanical couplings to seal carrier, and PE pipe complying with ASTM D 4976 for containment piping.
  - b. Fiberglass **OR** PE, **as directed**, sumps.
  - c. Watertight sump entry boots, pipe adapters with test ports and tubes, coaxial fittings, and couplings.
  - d. Minimum Operating Pressure Rating: **10 psig (69 kPa)**.
  - e. Plastic to Steel Pipe Transition Fittings: Factory-fabricated fittings with plastic end matching or compatible with carrier piping, and steel pipe end complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
  - f. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.
2. Rigid, Double-Containment Piping: Comply with UL 971.
  - a. RTRP: ASTM D 2996 or ASTM D 2997 carrier and containment piping and mechanical couplings to seal carrier and containment piping or individually bonded joints.
    - 1) Minimum Operating-Pressure Rating for RTRP **NPS 2 and NPS 3 (DN 50 and DN 80): 150 psig (1035 kPa)**.
    - 2) Minimum Operating-Pressure Rating for RTRP **NPS 4 and NPS 6 (DN 100 and DN 150): 125 psig (860 kPa)**. Compliance with UL 971 is not required for **NPS 6 (DN 150)** and larger piping.
    - 3) Fittings: RTRF complying with ASTM D 2996 or ASTM D 2997, and made by RTRP manufacturer; watertight sump entry boots, termination, or other end fittings.
  - b. Include design and fabrication of double-containment pipe and fitting assemblies with provision for field installation of cable leak-detection system in annular space between carrier and containment piping.

C. Piping Specialties

1. Flexible Connectors: Comply with UL 567.
  - a. Metallic Connectors:
    - 1) Listed and labeled for aboveground and underground applications by an NRTL acceptable to authorities having jurisdiction.
    - 2) Stainless-steel bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
    - 3) Minimum Operating Pressure: **150 psig (1035 kPa)**.
    - 4) End Connections: Socket, flanged, or threaded end to match connected piping.
    - 5) Maximum Length: **30 inches (762 mm)**.
    - 6) Swivel end, **50-psig (345-kPa)** maximum operating pressure.
    - 7) Factory-furnished anode.
  - b. Nonmetallic Connectors:
    - 1) Listed and labeled for underground applications by an NRTL acceptable to authorities having jurisdiction.
    - 2) PTFE bellows with woven, flexible, bronze or stainless-steel, wire-reinforcing protective jacket.
    - 3) Minimum Operating Pressure: **150 psig (1035 kPa)**.
    - 4) End Connections: Socket, flanged, or threaded end to match connected piping.
    - 5) Maximum Length: **30 inches (762 mm)**.
    - 6) Swivel end, **50-psig (345-kPa)** maximum operating pressure.
    - 7) Factory-furnished anode.
2. Y-Pattern Strainers:
  - a. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
  - b. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.

- c. Strainer Screen: 60 **OR** 80, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
  - d. CWP Rating: **125 psig (860 kPa)**.
3. Basket Strainers:
  - a. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
  - b. End Connections: Threaded ends for **NPS 2 (DN 50)** and smaller; flanged ends for **NPS 2-1/2 (DN 65)** and larger.
  - c. Strainer Screen: 60 **OR** 80, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
  - d. CWP Rating: **125 psig (860 kPa)**.
4. T-Pattern Strainers:
  - a. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
  - b. End Connections: Grooved ends.
  - c. Strainer Screen: 60 **OR** 80, **as directed**, -mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
  - d. CWP Rating: **750 psig (5170 kPa)**.
5. Manual Air Vents:
  - a. Body: Bronze.
  - b. Internal Parts: Nonferrous.
  - c. Operator: Screwdriver or thumbscrew.
  - d. Inlet Connection: **NPS 1/2 (DN 15)**.
  - e. Discharge Connection: **NPS 1/8 (DN 6)**.
  - f. CWP Rating: **150 psig (1035 kPa)**.
  - g. Maximum Operating Temperature: **225 deg F (107 deg C)**.
- D. Joining Materials
  1. Joint Compound and Tape: Suitable for fuel oil.
  2. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
  3. Brazing Filler Metals: Alloy with melting point greater than **1000 deg F (540 deg C)** complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.
  4. Bonding Adhesive for Fiberglass Piping: As recommended by fiberglass piping manufacturer.
- E. Manual Fuel-Oil Shutoff Valves
  1. See valve schedule in Part 1.3 for where each valve type is applied in various services.
  2. General Requirements for Metallic Valves, **NPS 2 (DN 50)** and Smaller for Liquid Service: Comply with UL 842.
    - a. CWP Rating: **125 psig (860 kPa)**.
    - b. Threaded Ends: Comply with ASME B1.20.1.
    - c. Dryseal Threads on Flare Ends: Comply with ASME B1.20.3.
    - d. Tamperproof Feature: Locking feature for valves indicated in the valve schedule.
    - e. Service Mark: Initials "WOG" shall be permanently marked on valve body.
  3. General Requirements for Metallic Valves, **NPS 2-1/2 (DN 65)** and Larger: Comply with UL 842.
    - a. CWP Rating: **125 psig (860 kPa)**.
    - b. Flanged Ends: Comply with ASME B16.5 for steel flanges.
    - c. Tamperproof Feature: Locking feature for valves indicated in the valve schedule.
    - d. Service Mark: Initials "WOG" shall be permanently marked on valve body.
  4. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
    - a. Body: Bronze, complying with ASTM B 584.
    - b. Ball: Chrome-plated brass.
    - c. Stem: Bronze; blowout proof.
    - d. Seats: Reinforced TFE; blowout proof.
    - e. Packing: Separate packnut with adjustable-stem packing threaded ends.

- f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
- g. CWP Rating: **600 psig (4140 kPa)**.
- h. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- 5. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim: MSS SP-110.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Ball: Chrome-plated bronze.
  - c. Stem: Bronze; blowout proof.
  - d. Seats: Reinforced TFE; blowout proof.
  - e. Packing: Threaded-body packnut design with adjustable-stem packing.
  - f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
  - g. CWP Rating: **600 psig (4140 kPa)**.
  - h. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- 6. Two-Piece, Regular-Port Bronze Ball Valves with Bronze Trim: MSS SP-110.
  - a. Body: Bronze, complying with ASTM B 584.
  - b. Ball: Chrome-plated bronze.
  - c. Stem: Bronze; blowout proof.
  - d. Seats: Reinforced TFE.
  - e. Packing: Threaded-body packnut design with adjustable-stem packing.
  - f. Ends: Threaded, flared, or socket as indicated in the valve schedule.
  - g. CWP Rating: **600 psig (4140 kPa)**.
  - h. Service Mark: Initials "WOG" shall be permanently marked on valve body.

#### F. Specialty Valves

- 1. Pressure Relief Valves: Comply with UL 842.
  - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
  - b. Body: Brass, bronze, or cast steel.
  - c. Springs: Stainless steel, interchangeable.
  - d. Seat and Seal: Nitrile rubber.
  - e. Orifice: Stainless steel, interchangeable.
  - f. Factory-Applied Finish: Baked enamel.
  - g. Maximum Inlet Pressure: **150 psig (1035 kPa)**.
  - h. Relief Pressure Setting: **60 psig (414 kPa)**.
- 2. Oil Safety Valves: Comply with UL 842.
  - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
  - b. Body: Brass, bronze, or cast steel.
  - c. Springs: Stainless steel.
  - d. Seat and Diaphragm: Nitrile rubber.
  - e. Orifice: Stainless steel, interchangeable.
  - f. Factory-Applied Finish: Baked enamel.
  - g. Manual override port.
  - h. Maximum Inlet Pressure: **60 psig (414 kPa)**.
  - i. Maximum Outlet Pressure: **3 psig (21 kPa)**.
- 3. Emergency Shutoff Valves: Comply with UL 842.
  - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
  - b. Single **OR** Double, **as directed**, poppet valve.
  - c. Body: ASTM A 126, cast iron.
  - d. Disk: FPM.
  - e. Poppet Spring: Stainless steel.
  - f. Stem: Plated brass.
  - g. O-Ring: FPM.
  - h. Packing Nut: PTFE-coated brass.
  - i. Fusible link to close valve at **165 deg F (74 deg C)**.



- j. Thermal relief to vent line pressure buildup due to fire.
  - k. Air test port.
  - l. Maximum Operating Pressure: **0.5 psig (3.45 kPa)**.
- 4. Mechanical Leak Detector: Comply with UL 842.
  - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
  - b. Body: ASTM A 126, cast iron.
  - c. O-Rings: Elastomeric compatible with fuel oil.
  - d. Piston and Stem Seals: PTFE.
  - e. Stem and Spring: Stainless steel.
  - f. Piston Cylinder: Burnished brass.
  - g. Indicated Leak Rate: Maximum **3 gph (3 mL/s) at 10 psig (69 kPa)**.
  - h. Leak Indication: Reduced flow.
- G. Vertical, Steel, Fuel-Oil AST
  - 1. Description:
    - a. UL 142, single-wall, vertical, steel tank.
    - b. UL 142 and STI F921, **as directed**, double-wall, vertical, steel tank; with primary- and secondary-containment walls and interstitial space.
  - 2. Construction: Fabricated with welded, carbon steel suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and maintained temperature up to **150 deg F (66 deg C)**.
- H. Horizontal, Steel, Fuel-Oil AST
  - 1. Description:
    - a. UL 142, single-wall, horizontal, steel tank.
    - b. UL 142 and STI F921, **as directed**, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and interstitial space.
  - 2. Construction: Fabricated with welded, carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to **150 deg F (66 deg C)**.
  - 3. Supports:
    - a. Manufacturer's standard structural steel welded to tank.
    - b. Manufacturer's standard type and number, steel or cast-iron cradles, for field installation.
- I. Containment-Dike, Steel, Fuel-Oil AST
  - 1. Description: UL 142 and STI F911, single-wall, horizontal, steel tank; with open or enclosed **OR** enclosed, **as directed**, secondary-containment dike with capacity greater than tank capacity.
  - 2. Construction: Fabricated with welded, carbon steel; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with maintained temperature up to **150 deg F (66 deg C)**.
- J. Insulated, Steel, Fuel-Oil AST
  - 1. Description: UL 142 and UL 2085 **OR** UL 142, UL 2085, and STI F941, **as directed**, thermally insulated and fire-resistant, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and insulation and with interstitial space.
  - 2. Construction: Fabricated with welded, carbon steel and insulation; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature according to UL 2085.
- K. Concrete-Vaulted, Steel, Fuel-Oil AST
  - 1. Description: UL 142 and UL 2085 **OR** UL 142, UL 2085, and STI F941, **as directed**; thermally insulated, fire-resistant and protected, double-wall, horizontal, steel tank; with primary- and secondary-containment walls and insulation and with interstitial space.



2. Construction: Fabricated with welded, carbon steel and insulation and encased in concrete that will protect from bullets; suitable for operation at atmospheric pressure and for storing fuel oil with specific gravity up to 1.1 and with test temperature according to UL 2085.
- L. Steel, Fuel-Oil UST With STI-P3
1. Description: UL 58 and STI P3, double-wall, horizontal, steel tank; with cathodic protection and electrical isolation.
    - a. Containment Method: STI-P3, Type I, with primary and secondary walls in contact **OR** Type II, with interstitial space, **as directed**.
  2. Construction: Fabricated with welded steel; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:
    - a. Depth of Bury: **3 feet (1 m)** from top of tank to finished surface.
    - b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
    - c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of **32,000 lb (14 515 kg)**.
  3. Corrosion-Protection System: Protect tank and factory-installed piping by engineered and installed corrosion-protection system according to STI P3, with means of monitoring cathodic protection.
- M. Composite, Steel, Fuel-Oil UST
1. Description: UL 58, double-wall, horizontal, composite tank; with coating complying with UL 1746 and STI F894.
    - a. Containment Method: STI F894, Type I, with primary and secondary walls in contact **OR** Type II, with interstitial space, **as directed**.
  2. Construction: Fabricated with welded steel and factory coating according to UL 1746 and STI F894; suitable for operation at atmospheric pressure and for storing liquids with specific gravity up to 1.1; fabricated for the following loads:
    - a. Depth of Bury: **3 feet (1 m)** from top of tank to finished surface.
    - b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
    - c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of **32,000 lb (14 515 kg)**.
- N. Jacketed, Steel, Fuel-Oil UST
1. Description: Jacketed, horizontal, steel tank; complying with UL 58, and with plastic or fiberglass jacket and corrosion-protection system according to UL 1746 and STI F922, **as directed**.
  2. Construction: Tank fabricated with welded carbon steel, and jacket fabricated with plastic or fiberglass and vacuum-sealed interstitial space; suitable for operation at atmospheric pressure and with integral leak-detection device. Tank fabricated for the following loads:
    - a. Depth of Bury: **3 feet (1 m)** from top of tank to finished surface.
    - b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.
    - c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of **32,000 lb (14 515 kg)**.
- O. FRP Fuel-Oil UST
1. Description: Horizontal, FRP UST; UL 1316, double wall, with interstitial space and integral, hydrostatic, leak-detection and monitoring system, **as directed**.
  2. Construction: Fabricated with fiberglass-reinforced polyester resins; suitable for operation at atmospheric pressure; fabricated for the following loads:
    - a. Depth of Bury: **3 feet (1 m)** from top of tank to finished surface.
    - b. External Hydrostatic Pressure: To withstand general buckling with safety factor of 2:1 if hole is fully flooded.

- c. Surface Loads: AASHTO's "Specifications for Highway Bridges," H-20 axle loads of **32,000 lb (14 515 kg)**.
- P. Shop Painting Of AST
1. Apply manufacturer's standard prime coat to exterior steel surface of AST and supports.
  2. Prepare exterior steel surface of AST and tank supports.
  3. Shop Cleaning: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3 **OR** SSPC-SP 10/NACE No. 2, **as directed**.
  4. After cleaning, remove dust or residue from cleaned surfaces.
  5. If surface develops rust before prime coat is applied, repeat surface preparation.
  6. Apply manufacturer's standard prime coat to shop-cleaned, dry surface same day as surface preparation.
  7. Apply manufacturer's standard two-component, epoxy finish coats.
- Q. Fuel-Oil AST Accessories
1. Tank Manholes (for horizontal tanks and some vertical tanks): **22-inch- (560-mm-)** minimum diameter; bolted, flanged, and gasketed; centered on top of tank.
  2. Tank Manholes (for vertical tanks): **22-inch- (560-mm-)** minimum diameter; bolted, flanged, and gasketed; on top and at side of tank.
  3. For Horizontal Tanks: Threaded pipe connection fittings on top of tank, for fill, supply, return, vent, sounding, and gaging. Include cast-iron plugs for shipping.
  4. For Vertical Tanks: Threaded pipe connection fittings on top or sides of tank as indicated, for fill, supply, return, vent, sounding, and gaging. Include cast-iron plugs for shipping.
  5. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.
  6. Lifting Lugs: For handling and installation.
  7. Ladders (for horizontal tanks and some vertical tanks): Carbon-steel ladder inside tank, anchored to top and bottom, and located as indicated. Include reinforcement of tank at bottom of ladder.
  8. Ladders (for vertical tanks): Carbon-steel ladder outside tank, anchored to top and side wall. Comply with requirements in Division 05 Section "Metal Fabrications" for exterior steel ladder.
    - a. Cage: Include welded steel cage around ladders for tanks **20 feet (6 m)** high or higher.
  9. Supply Tube: Extension of supply piping fitting into tank, terminating **6 inches (150 mm)** above tank bottom and cut at a **45-degree angle (1:1 slope)**.
  10. Sounding and Gage Tubes: Extension of fitting into tank, terminating **6 inches (150 mm)** above tank bottom and cut at a **45-degree angle (1:1 slope)**.
- R. Fuel-Oil UST Accessories
1. Tank Manholes: **22-inch- (560-mm-)** minimum diameter; bolted, flanged, and gasketed, with extension collar; for access to inside of tank.
  2. Steel Tank Masonry Supports: Two **6-by-6-by-3/8-inch (150-by-150-by-10-mm)** steel angles, **72 inches (1800 mm)** long, located longitudinally on tank on each side of manholes and continuously welded in place.
  3. Threaded pipe connection fittings on top of tank for fill, supply, return, vent, sounding, and gaging, in locations and of sizes indicated. Include cast-iron plugs for shipping.
  4. Striker Plates: Inside tank, on bottom below fill, vent, sounding, gage, and other tube openings.
  5. Lifting Lugs: For handling and installation.
  6. Ladders: Carbon-steel ladder inside tank, anchored to top and bottom. Include reinforcement of tank at bottom of ladder.
  7. Supply Tube: Extension of supply piping fitting into tank, terminating **6 inches (150 mm)** above tank bottom and cut at a **45-degree angle (1:1 slope)**.
  8. Sounding and Gage Tubes: Extension of fitting into tank, terminating **6 inches (150 mm)** above tank bottom and cut at a **45-degree angle (1:1 slope)**.
  9. Containment Sumps: Fiberglass **OR** PE, **as directed**, with sump base, add-on extension pieces as required, sump top, lid, and gasket-seal joints. Include sump entry boots for pipe penetrations through sidewalls.



10. Sump Entry Boots: Two-part pipe fitting for field assembly and of size required to fit over pipe. Include gaskets shaped to fit sump sidewall, sleeves, seals, and clamps as required for liquid-tight pipe penetrations.
11. Anchor Straps: Storage tank manufacturer's standard anchoring system, with straps, strap-insulating material, cables and turnbuckles, of strength at least one and one-half times maximum uplift force of empty tank without backfill in place.
12. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total weight of **3 oz./sq. yd. (101.7 g/sq. m)**.
13. Overfill Prevention Valves: Factory fabricated or shop or field assembled from manufacturer's standard components. Include drop tube, cap, fill nozzle adaptor, check valve mechanism or other devices, and vent if required to restrict flow at 95 percent of tank capacity and to provide complete shutoff of filling at 98 **OR 99, as directed**, percent of tank capacity.

S. Fuel-Oil Storage Tank Piping Specialties

1. Fitting Materials: Cast iron, malleable iron, brass, or corrosion-resistant metal; suitable for fuel-oil service.
  - a. Surface, Flush-Mounted Fittings: Waterproof and suitable for truck traffic.
  - b. Aboveground-Mounted Fittings: Weatherproof.
2. Spill-Containment Fill Boxes: Flush mounting, with drainage feature to drain oil into tank, threaded fill-pipe connection, and wrench operation.
3. Fill Boxes: Flush mounting, with threaded fill-pipe connection and wrench operation.
4. Locking Fill Boxes: Flush mounting, with locking-type inner fill cap for standard padlock and threaded fill-pipe connection.
5. Supply and Sounding Drop Tubes: Fuel-oil supply piping or fitting, inside tank, terminating **6 inches (150 mm)** above bottom of tank, and with end cut at a **45-degree angle (1:1 slope)**.
6. Pipe Adapters and Extensions: Compatible with piping and fittings.
7. Suction Strainers and Check Valves: Bronze or corrosion-resistant metal components.
8. Foot Valves and Antisiphon Valves: Poppet-type, bronze or corrosion-resistant metal components.
9. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.
10. Metal Manholes: **22-inch- (560-mm-)** minimum diameter frame and cover. Furnish manhole units of adequate size for access to fittings if size is not indicated.
11. Monitoring Well Caps: Locking pipe plug and manhole.

T. Submersible Fuel-Oil Pumps

1. Description: Comply with UL 79, UL 87, and UL 343.
  - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
  - b. Impeller: Turbine.
  - c. Housing and Volute: Cast iron.
  - d. Bearings: Bronze, self-lubricating.
  - e. Seals: Mechanical.
  - f. Shaft: Polished steel.
  - g. Suspension Piping: Telescoping to accommodate tank diameter and depth of bury.
  - h. Base: Steel.
  - i. Pressure Relief: Built in.
  - j. Discharge Check Valve: Built in.
  - k. Drive: Direct, close coupled.
2. Controls: Pump controller panel complying with UL 353 and UL 508C and with interlock and terminals for connections to fuel-oil-burning equipment **OR** diesel-driven fire pumps **OR** diesel-driven emergency generators **OR** diesel-fuel-oil dispenser, **as directed**.
  - a. Run pumps to maintain minimum manifold pressure with outdoor-air temperature less than **60 deg F (16 deg C)**.

- b. Run pumps on seven-day schedule.
  - c. Stage pumps on pressure at a common supply manifold.
  - d. Alternate pumps to equalize run time.
  - e. Alarm motor failure.
  - f. Manual reset dry-run protection. Stop pumps if fuel level falls below pump suction.
  - g. Deenergize and alarm pump locked rotor condition.
  - h. Alarm open circuit, high and low voltage.
  - i. Indicating lights for power on, run, and off normal conditions.
  - j. Interface with automatic control system is specified in Division 23 Section "Instrumentation And Control For Hvac" to control and indicate the following:
    - 1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
    - 2) Operating status.
    - 3) Alarm off-normal status.
3. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - b. Thermal-Overload Protection: Motor-winding temperature sensor.
  - c. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
- U. Simplex Fuel-Oil Transfer Pumps
1. Description: Comply with UL 343, and HI M109.
- a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
  - b. Type: Positive-displacement, rotary type.
  - c. Impeller: Steel gear with crescent **OR** Carbon vane, **as directed**.
  - d. Housing: Cast-iron foot mounted.
  - e. Bearings: Bronze, self-lubricating.
  - f. Shaft: Polished steel.
  - g. Seals: Mechanical.
  - h. Base: Steel.
  - i. Pressure Relief: Built in.
  - j. Discharge Check Valve: Built in.
2. Drive: V-belt with guard; gear reducer; or direct, close coupled **OR** V-belt with guard **OR** Gear reducer **OR** Direct, close coupled, **as directed**.
3. Controls:
- a. Run pump to maintain minimum manifold pressure with outdoor-air temperature less than **60 deg F (16 deg C)**.
  - b. Run pump on seven-day schedule.
  - c. Alarm motor failure.
  - d. Manual reset dry-run protection. Stop pump if fuel level falls below pump suction.
  - e. Deenergize and alarm pump locked rotor condition.
  - f. Alarm open circuit, high and low voltage.
  - g. Indicating lights for power on, run, and off normal conditions.
  - h. Interface with automatic control system is specified in Division 23 Section "Instrumentation And Control For Hvac" to control and indicate the following:
    - 1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
    - 2) Operating status.
    - 3) Alarm off-normal status.
4. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".



- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

V. Duplex **OR** Triplex, **as directed**, Fuel-Oil Transfer Pump Sets

1. Description: Comply with HI M109.
  - a. Listed and labeled for fuel-oil service by an NRTL acceptable to authorities having jurisdiction.
  - b. Type: Positive-displacement, rotary type.
  - c. Impeller: Steel gear with crescent **OR** Carbon vane, **as directed**.
  - d. Housing: Cast-iron foot mounted.
  - e. Bearings: Bronze, self-lubricating.
  - f. Shaft: Polished steel.
  - g. Seals: Mechanical.
  - h. Base: Steel.
  - i. Pressure Relief: Built in.
  - j. Discharge Check Valve: Built in.
2. Drive: V-belt with guard, gear reducer, or direct close coupled **OR** V-belt with guard **OR** Gear reducer **OR** Direct close coupled, **as directed**.
3. Controls:
  - a. Run pumps to maintain minimum manifold pressure with outdoor-air temperature less than **60 deg F (16 deg C)**.
  - b. Run pumps on seven-day schedule.
  - c. Stage pumps on pressure at a common supply manifold.
  - d. Alternate pumps to equalize run time.
  - e. Alarm motor failure.
  - f. Manual reset dry-run protection. Stop pumps if fuel level falls below pump suction.
  - g. Deenergize and alarm pump locked rotor condition.
  - h. Alarm open circuit, high and low voltage.
  - i. Indicating lights for power on, run, and off normal conditions.
  - j. Interface with automatic control system is specified in Division 23 Section "Instrumentation And Control For Hvac" to control and indicate the following:
    - 1) Start/stop pump set when required by schedule, fuel-fired appliance operation, day tank level control, or weather conditions.
    - 2) Operating status.
    - 3) Alarm off-normal status.
4. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
5. Piping Furnished with Pumps: Steel with ferrous fittings and threaded or welded joints.
6. Strainers Furnished with Pumps: Duplex, basket type with corrosion-resistant-metal-screen baskets.

W. Fuel Maintenance System

1. Description: Factory fabricated and wired fuel maintenance system for fuel-oil filtration; with enclosure, filter, fuel-oil pump, and controls; FMG approved, listed, and labeled by an NRTL acceptable to authorities having jurisdiction.
  - a. Enclosure: NEMA 250, Type 3R, painted steel containing pumps, filters, accessories, and controls. Hinged door on the front of enclosure.



- b. Pump: Comply with HI M109, steel-gear-with-crescent, positive-displacement, direct-coupled, rotary-type.
  - c. Materials: Cast-iron housing; bronze bearings; steel shaft; mechanical seals; and built-in, pressure relief bypass valve.
  - d. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - 2) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
  - e. Piping: Steel with malleable-iron fittings and threaded joints or wrought-steel fittings and welded joints.
  - f. Multistage Filter: Spin-on, replaceable types.
    - 1) Stage 1: 100-mesh strainer.
    - 2) Stage 2: Centrifuge to separate particulates and water from oil.
    - 3) Stage 3: Coalescing water and particulate filter.
    - 4) Stage 4: 30-micron particulate removal.
    - 5) Stage 5: 10-micron particulate removal.
    - 6) Stage 6: Minimum 99.5 percent water removal with see-through bowl and water-sensor probe.
    - 7) Stage 7: 1.5 **OR** 3, **as directed**, -micron particulate removal.
  - g. Multiple-Tank Manifolds:
    - 1) Manifold fabricated of Schedule 80, black steel pipe and threaded nipples for two **OR** three **OR** four, **as directed**, tanks.
    - 2) Solenoid valves for supply and return piping to each tank.
    - 3) Strainers for each tank supply connection.
  - h. Programmable Logic Controller:
    - 1) Alarm on maximum 15-in. Hg (51-kPa) vacuum at pump suction indicating plugged filter.
    - 2) Alarm on high water level in filter.
    - 3) Alarm leak in enclosure.
    - 4) Touch screen; with minimum 2-line, 20-character, backlit, LCD display.
    - 5) Controller strip heater with thermostat.
  - i. Interface with automatic control system is specified in Division 23 Section "Instrumentation And Control For Hvac" to control and indicate the following:
    - 1) Start/stop system when required by schedule.
    - 2) Operating status.
    - 3) Alarm off-normal status.
- X. Liquid-Level Gage System
- 1. Description: Calibrated, liquid-level gage system complying with UL 180 with floats **OR** UL 1238 with probes, **as directed**, or other sensors and remote annunciator panel.
  - 2. Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in gallons (liters), and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
  - 3. Controls: Electrical, operating on 120-V ac.
- Y. Leak-Detection And Monitoring System
- 1. Cable and Sensor System: Comply with UL 1238.
    - a. Calibrated, leak-detection and monitoring system with probes and other sensors and remote alarm panel for fuel-oil storage tanks and fuel-oil piping.
    - b. Include fittings and devices required for testing.
    - c. Controls: Electrical, operating on 120-V ac.
    - d. Calibrated, liquid-level gage complying with UL 180 with floats **OR** UL 1238 with probes, **as directed**, or other sensors and remote annunciator panel.



- e. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in **gallons (liters)**, and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
  - f. Controls: Electrical, operating on 120-V ac.
- 2. Hydrostatic System: Comply with UL 1238.
  - a. Calibrated, leak-detection and monitoring system with brine antifreeze solution, reservoir sensor, and electronic control panel to monitor leaks in inner and outer tank walls.
  - b. Include fittings and devices required for testing.
  - c. Controls: Electrical, operating on 120-V ac.
  - d. Calibrated, liquid-level gage complying with UL 180 with floats **OR** UL 1238 with probes, **as directed**, or other sensors and remote annunciator panel.
  - e. Remote Annunciator Panel: With visual and audible, high-tank-level and low-tank-level alarms, fuel indicator with registration in **gallons (liters)**, and overfill alarm. Include gage volume range that covers fuel-oil storage capacity.
  - f. Controls: Electrical, operating on 120-V ac.
- Z. Fuel Oil
  - 1. Fuel Oil: ASTM D 396, Grade No. 1 **OR** No. 2, **as directed**.
  - 2. Diesel Fuel Oil: ASTM D 975, Grade Low Sulfur **OR** No. 1-D, special-purpose **OR** No. 2-D, general-purpose, **as directed**, high volatility.
- AA. Sleeves
  - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
  - 2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- BB. Mechanical Sleeve Seals
  - 1. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
    - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe and sleeve.
    - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**.
    - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one nut and bolt for each sealing element.
- CC. Escutcheons
  - 1. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube and with OD that completely covers opening.
  - 2. One-Piece, Deep-Pattern Escutcheons: Deep-drawn brass with polished chrome-plated finish.
  - 3. One-Piece, Cast-Brass Escutcheons: With set screw.
    - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
  - 4. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
    - a. Finish: Polished chrome-plated **OR** Rough brass, **as directed**.
  - 5. One-Piece, Stamped-Steel Escutcheons: With set screw **OR** spring clips, **as directed**, and chrome-plated finish.
  - 6. Split-Plate, Stamped-Steel Escutcheons: With concealed **OR** exposed-rivet, **as directed**, hinge, set screw **OR** spring clips, **as directed**, and chrome-plated finish.
  - 7. One-Piece, Floor-Plate Escutcheons: Cast-iron floor plate.
  - 8. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.
- DD. Grout
  - 1. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.

- a. Characteristics: Posthardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
- b. Design Mix: **5000-psi (34.5-MPa)**, 28-day compressive strength.
- c. Packaging: Premixed and factory packaged.

EE. Labeling And Identifying

1. Detectable Warning Tape: Acid- and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of **6 inches (152 mm)** wide and **4 mils (0.1 mm)** thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to **30 inches (762 mm)** deep; colored yellow.

FF. Concrete Manholes

1. Precast Concrete Manhole Sections: **ASTM C 478 (ASTM C 478M)**, base and concentric-cone sections with integral ladder or steps.
2. Cast-Iron Frame and Cover: Heavy-duty, water-resistant, cast-iron manhole frame, gasket, and bolted cover; **24-inch- (609-mm-)** diameter, inside opening dimension; **8-inch (203-mm)** frame riser height.

GG. Source Quality Control

1. Pressure test and inspect fuel-oil storage tanks, after fabrication and before shipment, according to ASME and the following:
  - a. Vertical **OR** Horizontal, **as directed**, Single-Wall Steel ASTs: UL 142.
  - b. Vertical **OR** Horizontal, **as directed**, Double-Wall Steel ASTs: UL 142, STI F921, and STI R931.
  - c. Horizontal, Containment-Dike, Steel ASTs: UL 142 and STI F911.
  - d. Horizontal, Concrete-Vaulted **OR** Concrete-Vaulted and Insulated **OR** Insulated, **as directed**, Steel ASTs: UL 142 and UL 2085.
  - e. Horizontal, Steel USTs with the STI-P3 Corrosion-Protection System: UL 58 and STI P3.
  - f. Composite **OR** Composite and Jacketed **OR** Jacketed, **as directed**, Steel USTs: UL 58.
  - g. FRP USTs: UL 1316.
2. Affix standards organization's code stamp.

1.3 EXECUTION

A. Earthwork

1. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

B. Preparation

1. Close equipment shutoff valves before turning off fuel oil to premises or piping section.
2. Comply with NFPA 30 and NFPA 31 requirements for prevention of accidental ignition.

C. Outdoor Piping Installation

1. Install underground fuel-oil piping buried at least **18 inches (457 mm)** below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
  - a. If fuel-oil piping is installed with less than **12 inches (305 mm)** of cover to finished grade, install in containment piping.
2. Steel Piping with Protective Coating:
  - a. Apply joint cover kits to pipe after joining, to cover, seal, and protect joints.
  - b. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer. Review protective coating damage prior to repair.  
**OR**  
Replace pipe having damaged PE coating with new pipe.

3. Install double-containment, fuel-oil pipe at a minimum slope of 1 percent downward toward fuel-oil storage tank sump.
4. Install vent pipe at a minimum slope of 2 percent downward toward fuel-oil storage tank sump.
5. Assemble and install entry boots for pipe penetrations through sump sidewalls for liquid-tight joints.
6. Install metal pipes and tubes, fittings, valves, and flexible connectors at piping connections to AST and UST.
7. Install fittings for changes in direction in rigid pipe.
8. Install system components with pressure rating equal to or greater than system operating pressure.
9. Aboveground, Exterior-Wall Pipe Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Install sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
10. Underground, Exterior-Wall Pipe Penetrations: Install cast-iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
11. Mechanical Sleeve Seal Installation: Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
12. Install pressure gage on suction **OR** suction and discharge, **as directed**, from each pump. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".

D. Indoor Piping Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
2. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
3. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
4. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
5. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
6. Install piping free of sags and bends.
7. Install fittings for changes in direction and branch connections.
8. Install escutcheons for penetrations of walls, ceilings, and floors.
  - a. New Piping:
    - 1) Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
    - 2) Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome-plated finish.  
**OR**  
Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
    - 3) Piping at Ceiling Penetrations in Finished Spaces: One-piece **OR** Split-casting, **as directed**, cast-brass type with polished chrome-plated finish.  
**OR**  
Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type **OR** Split-plate, stamped-steel type with concealed hinge, **as directed**, and set screw.
    - 4) Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.  
**OR**

- Piping in Unfinished Service Spaces: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
- 5) Piping in Equipment Rooms: One-piece, cast-brass type.  
**OR**  
Piping in Equipment Rooms: One-piece, stamped-steel type with set screw **OR** spring clips, **as directed**.
- 6) Piping at Floor Penetrations in Equipment Rooms: One-piece, floor-plate type.
- 9. Existing Piping:
  - 1) Piping at Wall and Floor Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.  
**OR**  
Piping at Wall and Floor Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and spring clips.
  - 2) Piping at Ceiling Penetrations in Finished Spaces: Split-casting, cast-brass type with chrome-plated finish.  
**OR**  
Piping at Ceiling Penetrations in Finished Spaces: Split-plate, stamped-steel type with concealed hinge and set screw.
  - 3) Piping in Unfinished Service Spaces: Split-casting, cast-brass type with polished chrome-plated **OR** rough-brass, **as directed**, finish.  
**OR**  
Piping in Unfinished Service Spaces: Split-plate, stamped-steel type with concealed **OR** exposed-rivet, **as directed**, hinge and set screw or spring clips.
  - 4) Piping in Equipment Rooms: Split-casting, cast-brass type.  
**OR**  
Piping in Equipment Rooms: Split-plate, stamped-steel type with set screw or spring clips.
  - 5) Piping at Floor Penetrations in Equipment Rooms: Split-casting, floor-plate type.
- 10. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
- 11. Verify final equipment locations for roughing-in.
- 12. Comply with requirements for equipment specifications in Division 14 AND Division 21 for roughing-in requirements.
- 13. Conceal pipe installations in walls, pipe spaces, or utility spaces; above ceilings; below grade or floors; and in floor channels unless indicated to be exposed to view.
- 14. Prohibited Locations:
  - a. Do not install fuel-oil piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
  - b. Do not install fuel-oil piping in solid walls or partitions.
- 15. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- 16. Connect branch piping from top or side of horizontal piping.
- 17. Install unions in pipes **NPS 2 (DN 50)** and smaller at final connection to each piece of equipment and elsewhere as indicated. Unions are not required on flanged devices.
- 18. Do not use fuel-oil piping as grounding electrode.
- 19. Install Y-pattern **OR** basket **OR** T-pattern, **as directed**, strainer on inlet side of fuel-oil pump.

E. Valve Installation

- 1. Install manual fuel-oil shutoff valves on branch connections to fuel-oil appliance.
- 2. Install valves in accessible locations.
- 3. Protect valves from physical damage.
- 4. Install metal tag attached with metal chain indicating fuel-oil piping systems.
- 5. Identify valves as specified in Division 23 Section "Identification For Hvac Piping And Equipment".
- 6. Install oil safety valves at inlet of each oil-fired appliance.



7. Install pressure relief valves in distribution piping between the supply and return lines.
8. Install one-piece, bronze ball valve with hose end connection at low points in fuel-oil piping.
9. Install manual air vents at high points in fuel-oil piping.
10. Install emergency shutoff valves at dispensers (for systems with fuel-oil or diesel-fuel-oil dispensers).

F. Piping Joint Construction

1. Ream ends of pipes and tubes and remove burrs.
2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
  - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
  - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
4. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to "Quality Assurance" Article.
  - a. Bevel plain ends of steel pipe.
  - b. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
5. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
6. Flanged Joints: Install gasket material, size, type, and thickness for service application. Install gasket concentrically positioned.
7. Flared Joints: Comply with SAE J513. Tighten finger tight, then use wrench according to fitting manufacturer's written recommendations. Do not overtighten.
8. Fiberglass-Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

G. Fuel-Oil AST Installation

1. Install tank bases and supports.
2. Connect piping and vent fittings.
3. Install ground connections.
4. Install tank leak-detection and monitoring devices.
5. Install steel ASTs according to STI R912.
6. Install insulated and concrete-vaulted, steel ASTs according to STI R942.
7. Fill storage tanks with fuel oil.

H. Fuel-Oil UST Installation

1. Excavate to sufficient depth for a minimum of **3 feet (1 m)** of earth cover from top of tank to finished grade. Allow for cast-in-place, concrete-ballast base plus **6 inches (150 mm)** of sand or pea gravel between ballast base and tank. Extend excavation at least **12 inches (300 mm)** around perimeter of tank.
2. Set tie-down eyelets for hold-down straps in concrete-ballast base and tie to reinforcing steel.
3. Place **6 inches (152 mm)** of clean sand or pea gravel on top of concrete-ballast base.
4. Set tank on fill materials and install hold-down straps.
5. Connect piping.
6. Install tank leak-detection and monitoring devices.
7. Install containment sumps.
8. Backfill excavation with clean sand or pea gravel in **12-inch (305-mm)** lifts and tamp backfill lift to consolidate.
9. Install filter mat between top of backfill material and earth fill.
10. Install steel USTs with the STI-P3 corrosion-protection system according to STI R821 and STI R891. Protect anodes during tank placement and backfilling operations.



11. Install composite, steel USTs according to STI R913 and STI R891.
12. Install jacketed, steel USTs according to STI R923 and STI R891.
13. Install FRP USTs with FRP hold-down straps, manhole extensions, and manhole risers.
14. Fill storage tanks with fuel oil.

I. Hanger And Support Installation

1. Pipe hanger and support and equipment support materials and installation requirements are specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
2. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
  - a. **NPS 1-1/4 (DN 32)** and Smaller: Maximum span, **84 inches (2130 mm)**; minimum rod size, **3/8 inch (10 mm)**.
  - b. **NPS 1-1/2 (DN 40)**: Maximum span, **108 inches (2740 mm)**; minimum rod size, **3/8 inch (10 mm)**.
  - c. **NPS 2 (DN 50)**: Maximum span, **10 feet (3 m)**; minimum rod size, **3/8 inch (10 mm)**.
  - d. **NPS 2-1/2 (DN 65)**: Maximum span, **11 feet (3.4 m)**; minimum rod size, **1/2 inch (13 mm)**.
  - e. **NPS 3 (DN 80)**: Maximum span, **12 feet (3.7 m)**; minimum rod size, **1/2 inch (13 mm)**.
  - f. **NPS 4 (DN 100)**: Maximum span, **13 feet (4 m)**; minimum rod size, **5/8 inch (16 mm)**.
3. Support vertical steel pipe at each floor and at spacing not greater than **15 feet (4.5 m)**.
4. Install hangers for horizontal, drawn-temper copper tubing with the following maximum spacing and minimum rod sizes:
  - a. **NPS 3/4 (DN 20)** and Smaller: Maximum span, **60 inches (1524 mm)**; minimum rod size, **3/8 inch (10 mm)**.
  - b. **NPS 1 (DN 25)**: Maximum span, **72 inches (1830 mm)**; minimum rod size, **3/8 inch (10 mm)**.
  - c. **NPS 1-1/4 (DN 32)**: Maximum span, **84 inches (2130 mm)**; minimum rod size, **3/8 inch (10 mm)**.
  - d. **NPS 1-1/2 and NPS 2 (DN 40 and DN 50)**: Maximum span, **96 inches (2440 mm)**; minimum rod size, **3/8 inch (10 mm)**.
  - e. **NPS 2-1/2 (DN 65)**: Maximum span, **108 inches (2740 mm)**; minimum rod size, **1/2 inch (13 mm)**.
  - f. **NPS 3 (DN 80)**: Maximum span, **10 feet (3 m)**; minimum rod size, **1/2 inch (13 mm)**.
  - g. **NPS 4 (DN 100)**: Maximum span, **11 feet (3.4 m)**; minimum rod size, **5/8 inch (16 mm)**.
5. Support vertical copper tube at each floor and at spacing not greater than **10 feet (3 m)**.

J. Fuel-Oil Pump Installation

1. Submersible Pumps:
  - a. Suspend pumps from supply piping and anchored to bottom of tank.
2. Transfer Pumps:
  - a. Install pumps with access space for periodic maintenance including removal of motors, impellers, and accessories.
  - b. Set pumps on and anchor to concrete base.
3. Install two-piece, full-port ball valves at suction and discharge of pumps.
4. Install mechanical leak-detector valves at pump discharge.
5. Install Y-pattern **OR** basket **OR** T-pattern, **as directed**, strainer on inlet side of simplex fuel-oil pumps.
6. Install check valve on discharge of simplex fuel-oil pumps.
7. Install suction piping with minimum fittings and change of direction.
8. Install vacuum and pressure gage, upstream and downstream respectively, at each pump to measure the differential pressure across the pump. Pressure gages are specified in Division 23 Section "Meters And Gages For Hvac Piping".

K. Fuel Maintenance System Installation

1. Install suction line, with foot valve, at one end of storage tank, **1 inch (25 mm)** from the bottom of tank.
2. Install return line at the opposite end of storage tank from suction line.



- L. Liquid-Level Gage System Installation
1. Install liquid-level gage system. Locate panel inside building where indicated.
- M. Leak-Detection And Monitoring System Installation
1. Install leak-detection and monitoring system. Install alarm panel inside building where indicated.
    - a. Double-Wall, Fuel-Oil Storage Tanks: Install probes **OR** Install probes or use factory-installed integral probes **OR** Use factory-installed integral probes, **as directed**, in interstitial space.
    - b. Single-Wall, Fuel-Oil Storage Tanks: Install probes as indicated.
    - c. Double-Containment, Fuel-Oil Piping: Install leak-detection sensor probes in fuel-oil storage tank containment sumps and at low points in piping **OR** cable probes in interstitial space of double-containment piping, **as directed**.
    - d. Install liquid-level gage.
- N. Connections
1. Install piping adjacent to equipment to allow service and maintenance.
  2. Install unions, in piping **NPS 2 (DN 50)** and smaller, adjacent to each valve and at final connection to each piece of equipment having threaded pipe connection.
  3. Install flanges, in piping **NPS 2-1/2 (DN 65)** and larger, adjacent to flanged valves and at final connection to each piece of equipment having flanged pipe connection.
  4. Connect piping to equipment with ball valve and union. Install union between valve and equipment.
  5. Install flexible piping connectors at final connection to burners or oil-fired appliances that must be moved for maintenance access.
- O. Labeling And Identifying
1. Nameplates, pipe identification, and signs are specified in Division 23 Section "Identification For Hvac Piping And Equipment".  
**OR**  
Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on or near each service regulator, service meter, and earthquake valve.
    - a. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
  2. Install detectable warning tape directly above fuel-oil piping, **12 inches (304 mm)** below finished grade, except **6 inches (152 mm)** below subgrade under pavements and slabs. Terminate tracer wire in an accessible area, and identify as "tracer wire" for future use with plastic-laminate sign.
    - a. Piping: Over underground fuel-oil distribution piping.
    - b. Fuel-Oil Storage Tanks: Over edges of each UST.
- P. Field Painting Of AST
1. If shop painting AST, prepare and touch up damaged exterior surface of AST and supports, **as directed**, as specified in "Shop Painting of AST" Article.
  2. If field painting AST, prepare exterior steel surface of AST and tank supports, **as directed**.
  3. Field Cleaning: After fabrication, blast clean according to SSPC-SP 6/NACE No. 3 **OR** SSPC-SP 10/NACE No. 2, **as directed**.
  4. After cleaning, remove dust or residue from cleaned surfaces.
  5. If surfaces develop rust before prime coat is applied, repeat surface preparation.
  6. Prepare surface of AST and supports, **as directed**, and apply painting systems according to specifications in Division 09 Section "High-performance Coatings" for severe **OR** moderate **OR** mild, **as directed**, environment high-gloss **OR** semigloss, **as directed**, finish for ferrous metal.
- Q. Field Painting Of Aboveground Piping
1. Comply with requirements in Division 07 for painting interior and exterior fuel-oil piping.

2. Paint exposed, exterior metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
    - a. Alkyd System: MPI EXT 5.1D.
      - 1) Prime Coat: Alkyd anticorrosive metal primer.
      - 2) Intermediate Coat (for a Premium Grade system): Exterior alkyd enamel matching topcoat.
      - 3) Topcoat: Exterior alkyd enamel (flat) **OR** (semigloss) **OR** (gloss), **as directed**.
      - 4) Color: Gray, **as directed**.
  3. Paint exposed, interior metal piping, valves, and piping specialties, except components with factory-applied paint or protective coating.
    - a. Latex Over Alkyd Primer System: MPI INT 5.1Q.
      - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
      - 2) Intermediate Coat (for a Premium Grade system): Interior latex matching topcoat.
      - 3) Topcoat: Interior latex (flat) **OR** (low sheen) **OR** (eggshell) **OR** (satin) **OR** (semigloss) **OR** (gloss), **as directed**.
      - 4) Color: Gray, **as directed**.
    - b. Alkyd System: MPI INT 5.1E.
      - 1) Prime Coat: Alkyd anticorrosive **OR** Quick-drying alkyd, **as directed**, metal primer.
      - 2) Intermediate Coat (for a Premium Grade system): Interior alkyd matching topcoat.
      - 3) Topcoat: Interior alkyd (flat) **OR** (eggshell) **OR** (semigloss) **OR** (gloss), **as directed**.
      - 4) Color: Gray, **as directed**.
  4. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.
- R. Concrete Bases
1. Concrete Bases: Anchor equipment to concrete base according to equipment manufacturer's written instructions and according to seismic codes at Project.
    - a. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit.
    - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (457-mm)** centers around the full perimeter of the base.
    - c. Install epoxy-coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
    - d. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
    - f. Use **3000-psig (20.7-MPa)**, **unless directed otherwise**, 28-day, compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
- S. Field Quality Control
1. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  2. Tests and Inspections:
    - a. Tanks: Minimum hydrostatic or compressed-air test pressures for fuel-oil storage tanks that have not been factory tested and do not bear the ASME code stamp or a listing mark acceptable to authorities having jurisdiction:
      - 1) Single-Wall Tanks: Minimum **3 psig (20.7 kPa)** and maximum **5 psig (34.5 kPa)**.
      - 2) Double-Wall Tanks:
        - a) Inner Tanks: Minimum **3 psig (20.7 kPa)** and maximum **5 psig (34.5 kPa)**.
        - b) Interstitial Space: Minimum **3 psig (20.7 kPa)** and maximum **5 psig (34.5 kPa)**, or **5.3-in. Hg (18-kPa)** vacuum.



- 3) Where vertical height of fill and vent pipes is such that the static head imposed on the bottom of the tank is greater than **10 psig (69 kPa)**, hydrostatically test the tank and fill and vent pipes to a pressure equal to the static head thus imposed.
- 4) Maintain the test pressure for one hour.
- b. Piping: Minimum hydrostatic or pneumatic test-pressures measured at highest point in system:
  - 1) Fuel-Oil Distribution Piping: Minimum **5 psig (34.5 kPa)** for minimum 30 minutes.
  - 2) Fuel-Oil, Double-Containment Piping:
    - a) Carrier Pipe: Minimum **5 psig (34.5 kPa)** for minimum 30 minutes.
    - b) Containment Conduit: Minimum **5 psig (34.5 kPa)** for minimum 60 minutes.
  - 3) Suction Piping: Minimum **20-in. Hg (68 kPa)** for minimum 30 minutes.
  - 4) Isolate storage tanks if test pressure in piping will cause pressure in storage tanks to exceed **10 psig (69 kPa)**.
- c. Inspect and test fuel-oil piping according to NFPA 31, "Tests of Piping" Paragraph; and according to requirements of authorities having jurisdiction.
- d. Test liquid-level gage for accuracy by manually measuring fuel-oil levels at not less than three **OR** four **OR** five, **as directed**, different depths while filling tank and checking against gage indication.
- e. Test leak-detection and monitoring system for accuracy by manually operating sensors and checking against alarm panel indication.
- f. Start fuel-oil transfer pumps to verify for proper operation of pump and check for leaks.
- g. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- h. Bleed air from fuel-oil piping using manual air vents.
3. Fuel-oil piping and equipment will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

#### T. Outdoor Piping Schedule

1. Underground fuel-oil piping shall be one of the following. Size indicated is carrier-pipe size.
  - a. Flexible, double-containment piping.
  - b. Rigid, double-containment piping.
2. Underground fuel-oil-tank fill and vent piping shall be one of the following:
  - a. **NPS 2 (DN 50)** and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints. Coat pipe and fittings with protective coating for steel piping.
  - b. **NPS 2-1/2 (DN 65)** and Larger: Steel pipe, steel welding fittings, and welded joints. Coat pipe and fittings with protective coating for steel piping.
3. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
4. Aboveground fuel-oil piping shall be one of the following:
  - a. **NPS 2 (DN 50)** and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints.
  - b. **NPS 2-1/2 (DN 65)** and Larger: Steel pipe, steel welding fittings, and welded joints.
  - c. Annealed **OR** Drawn, **as directed**, -temper copper tube with wrought-copper fittings and brazed joints.

#### U. Indoor Piping Schedule

1. Aboveground fuel-oil piping shall be one of the following:
  - a. **NPS 1/2 (DN 15)** and Smaller: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints **OR** Annealed-temper copper pipe, wrought copper fittings, and brazed or flared joints, **as directed**.
  - b. **NPS 5/8 to NPS 2 (DN 18 to DN 50)**: Steel pipe, steel or malleable-iron threaded fittings, and threaded joints **OR** Drawn temper copper pipe, wrought copper fittings, and brazed joints, **as directed**.

- c. **NPS 2-1/2 (DN 65)** and Larger: Steel pipe, steel fittings, and welded or flanged joints **OR** Drawn temper copper pipe, wrought copper fittings, and brazed or flanged joints, **as directed**.
  - d. Steel pipe with malleable-iron fittings and threaded joints.
  - e. Steel pipe with wrought-steel fittings and welded joints.
  - f. Annealed-temper copper tube, brass fittings, and flared joints.
  - g. Drawn-temper copper tubing, copper fittings, and brazed joints.
- V. Aboveground Manual Fuel-Oil Shutoff Valve Schedule
- 1. Distribution piping valves for pipe **NPS 2 (DN 50)** and smaller shall be one of the following:
    - a. One-piece, bronze ball valve with bronze trim.
    - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
  - 2. Distribution piping valves for pipe **NPS 2-1/2 (DN 65)** and larger shall be one of the following:
    - a. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.
    - b. Bronze, nonlubricated **OR** lubricated, **as directed**, plug valve.
  - 3. Valves in branch piping for single appliance shall be one of the following:
    - a. One-piece, bronze ball valve with bronze trim.
    - b. Two-piece, full **OR** regular, **as directed**, -port, bronze ball valves with bronze trim.

END OF SECTION 23 21 13 23

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## SECTION 23 21 13 23a - RADIANT HEATING PIPING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for radiant heating piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes radiant heating piping, including pipes, fittings, and piping specialties.

#### C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. PEX: Crosslinked polyethylene.
3. PEX/AL/PEX: Crosslinked polyethylene/aluminum/crosslinked polyethylene.

#### D. Submittals

1. Product Data: For each type of radiant heating pipe, fitting, manifold, specialty, and control.
  - a. For radiant heating piping and manifolds, include pressure and temperature rating, oxygen-barrier performance, fire-performance characteristics, and water flow and pressure drop characteristics.
2. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
3. Operation and Maintenance Data.

### 1.2 PRODUCTS

#### A. PEX Pipe And Fittings

1. Pipe Material: PEX plastic according to ASTM F 876.
2. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.
3. Fittings: ASTM F 1807, metal insert and copper crimp rings.
4. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 180 deg F (82 deg C).

#### B. PEX/AL/PEX Pipe And Fittings

1. Pipe Material: PEX plastic bonded to the inside and outside of a welded aluminum tube according to ASTM F 1281.
2. Oxygen Barrier: Limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.
3. Fittings: ASTM F 1974, metal insert fittings with split ring and compression nut (compression joint) or metal insert fittings with copper crimp rings (crimp joint).
4. Flame-Spread and Smoke-Developed Indexes: 25 and 50 or less, respectively, tested according to ASTM E 84.
5. Pressure/Temperature Rating: Minimum 100 psig (690 kPa) and 210 deg F (99 deg C).

#### C. EPDM Pipe And Fittings

1. Pipe Material: Crosslinked EPDM inner and outer tubes.
2. Wall Thickness: Minimum 0.125 inch (3.2 mm).
3. Oxygen Barrier: Ductile aluminum foil layer applied to the inner tube to limit oxygen diffusion through the pipe to maximum 0.10 mg per cu. m/day at 104 deg F (40 deg C) according to DIN 4726.



4. Reinforcing Braid: Braided-aluminum wire between the inner and outer tube.
5. Fittings: ASTM F 1807, copper with stainless-steel crimps or clamps.
6. Pressure/Temperature Rating: Minimum **100 psig (690 kPa)** and **210 deg F (99 deg C)**.

D. Distribution Manifolds

1. Manifold: Minimum **NPS 1 (DN 25)**, brass **OR** copper **OR** modular plastic **OR** stainless steel, **as directed**.
2. Main Shutoff Valves:
  - a. Factory installed on supply and return connections.
  - b. Two **OR** Three, **as directed**,-piece body.
  - c. Body: Brass or bronze.
  - d. Ball: Chrome-plated bronze.
  - e. Seals: PTFE.
  - f. CWP Rating: **150 psig (1035 kPa)**.
  - g. Maximum Operating Temperature: **225 deg F (107 deg C)**.
3. Manual Air Vents:
  - a. Body: Bronze.
  - b. Internal Parts: Nonferrous.
  - c. Operator: Key furnished with valve, or screwdriver bit.
  - d. Inlet Connection: **NPS 1/2 (DN 15)**.
  - e. Discharge Connection: **NPS 1/8 (DN 6)**.
  - f. CWP Rating: **150 psig (1035 kPa)**.
  - g. Maximum Operating Temperature: **225 deg F (107 deg C)**.
4. Balancing Valves:
  - a. Body: Plastic or bronze, ball or plug, or globe cartridge type.
  - b. Ball or Plug: Brass or stainless steel.
  - c. Globe Cartridge and Washer: Brass with EPDM composition washer.
  - d. Seat: PTFE.
  - e. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.

**OR**

Differential Pressure Gage Connections: Integral seals for portable meter to measure loss across calibrated orifice.

  - f. Handle Style: Lever or knob, with memory stop to retain set position if used for shutoff.
  - g. CWP Rating: Minimum **125 psig (860 kPa)**.
  - h. Maximum Operating Temperature: **250 deg F (121 deg C)**.
5. Zone Control Valves:
  - a. Body: Plastic or bronze, ball or plug, or globe cartridge type.
  - b. Ball or Plug: Brass or stainless steel.
  - c. Globe Cartridge and Washer: Brass with EPDM composition washer.
  - d. Seat: PTFE.
  - e. Actuator: Replaceable electric motor.
  - f. CWP Rating: Minimum **125 psig (860 kPa)**.
  - g. Maximum Operating Temperature: **250 deg F (121 deg C)**.
6. Thermometers:
  - a. Mount on supply and return connections.
  - b. Case: Dry type, metal or plastic, **2-inch (50-mm)** diameter.
  - c. Element: Bourdon tube or other type of pressure element.
  - d. Movement: Mechanical, connecting element and pointer.
  - e. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
  - f. Pointer: Black metal.
  - g. Window: Plastic.
  - h. Connector: Rigid, back type.
  - i. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem.

- j. Accuracy: Plus or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.
- 7. Mounting Brackets: Copper, or plastic or copper-clad steel, where in contact with manifold.
- E. Piping Specialties
  - 1. Cable Ties:
    - a. Fungus-inert, self-extinguishing, 1-piece, self-locking, Type 6/6 nylon cable ties.
    - b. Minimum Width: 1/8 inch (3 mm).
    - c. Tensile Strength: 20 lb (9 kg), minimum.
    - d. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
  - 2. Floor-Mounting Staples:
    - a. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
    - b. Minimum Thickness: 3/32 inch (2.4 mm).
    - c. Width: Minimum, wider than tubing.
  - 3. Floor-Mounting Clamps:
    - a. Two bolt, steel, with corrosion-resistant coating and smooth finish without sharp edges.
    - b. Minimum Thickness: 3/32 inch (2.4 mm).
    - c. Width: Minimum, wider than tubing.
  - 4. Floor Mounting Tracks:
    - a. Aluminum or plastic channel track with smooth finish, no sharp edges.
    - b. Minimum Thickness: 1/16 inch (1.6 mm).
    - c. Slot Width: Snap fit to hold tubing.
    - d. Slot Spacing: 2-inch (50-mm) OR 3-inch (75-mm), as directed, intervals.
  - 5. Channeled Subfloor:
    - a. Plywood, APA-rated subfloor panel, composed of premium, tongue-and-groove, 7-layer, Douglas fir structural subfloor panels.
    - b. Particleboard manufactured to meet Federal Housing Authority standards of less than 0.3-ppm formaldehyde.
    - c. Clad panel with minimum 0.025-inch- (0.635-mm-) thick aluminum recessed in the grooves sized to maintain contact with radiant piping.
  - 6. Modular Interlocking Blocks:
    - a. Polypropylene snap-together blocks with grooves to support piping.
    - b. Galvanized sheet metal or aluminum emission plates.
    - c. Natural mineralboard cover panel.
  - 7. Heat-Emission Plates:
    - a. Formed aluminum suitable for radiant heating piping.
    - b. Minimum Thickness: 1/16 inch (1.6 mm).
    - c. Slot Width: Snap fit to maintain pressure fit on tubing.
- F. Controls
  - 1. Temperature-control devices and sequence of operations are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
  - 2. Wall-Mounting Thermostat:
    - a. Minimum temperature range from 50 to 90 deg F (10 to 32 deg C).
    - b. Manually operated with on-off switch.
    - c. Day and night setback and clock program with minimum four periods per day.
    - d. Operate pumps or open zone control valves if room temperature falls below the thermostat setting, and stop pumps or close zone control valves when room temperature rises above the thermostat setting.
  - 3. Heated-Panel Thermostat:
    - a. Remote bulb unit with adjustable temperature range from 50 to 90 deg F (10 to 32 deg C).
    - b. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump or zone control valve.
    - c. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
    - d. Stop pump or close zone control valves if heated-panel thermostat setting is exceeded.

- e. Corrosion-resistant, waterproof control enclosure.
- 4. Heated-Panel Thermostat with Outdoor Temperature Reset:
  - a. Remote bulb unit with adjustable temperature range from **50 to 90 deg F (10 to 32 deg C)**.
  - b. Snap action; open-on-rise, single-pole switch with minimum current rating adequate for connected pump and zone control valve.
  - c. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing radiant panel temperature.
  - d. Remote bulb on capillary tube, resistance temperature device, or thermistor for directly sensing outdoor-air temperature.
  - e. Operate zone control valves to reset supply-water temperature inversely with outdoor-air temperature as follows:
    - 1) Low outdoor-air temperature, **zero deg F (minus 18 deg C)** with high supply-water temperature **110 deg F (43 deg C)**.
    - 2) High outdoor-air temperature, **60 deg F (16 deg C)** with low supply-water temperature **70 deg F (21 deg C)**.
  - f. Corrosion-resistant, waterproof control enclosure.
- 5. Precipitation and Temperature Sensor:
  - a. Microprocessor-based **OR** Automatic, **as directed**, control with manual on, automatic, and standby/reset switch.
  - b. Precipitation and temperature sensors shall sense the surface conditions of pavement and shall be programmed to operate pump and zone control valves as follows:
    - 1) Temperature Span: **34 to 44 deg F (1 to 7 deg C)**.
    - 2) Adjustable Delay Off Span: 30 to 90 minutes.
    - 3) Start Pump or Open Zone Control Valves: Following two-minute delay if ambient temperature is below set point and precipitation is detected.
    - 4) Stop Pump or Close Zone Control Valves: On detection of a dry surface plus time delay.
  - c. Corrosion-proof and waterproof enclosure suitable for outdoor mounting, for controls and precipitation and temperature sensors.
  - d. Minimum 30-A contactor to start pump and open valves.
  - e. Precipitation sensor shall be mounted in pavement.
  - f. Provide relay with contacts to indicate operational status, on or off, for interface with central HVAC control system workstation.

### 1.3 EXECUTION

#### A. Applications

- 1. Install the following types of radiant heating piping for the applications described:
  - a. Piping in Exterior Pavement: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
  - b. Piping in Interior Reinforced-Concrete Floors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
  - c. Piping in Level Fill Concrete Floors (Not Reinforced): EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
  - d. Piping in Ceilings: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
  - e. Piping in Subfloors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.
  - f. Piping below Wood Floors: EPDM **OR** PEX **OR** PEX/AL/PEX, **as directed**.

#### B. Installation

- 1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop or Coordination Drawings.
- 2. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.

3. Connect radiant piping to manifold in a reverse-return arrangement.
4. Do not bend pipes in radii smaller than manufacturer's minimum bend radius dimensions.
5. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Division 08 Section "Access Doors And Frames".
6. Refer to Division 23 Section "Hydronic Piping" for pipes and connections to hydronic systems and for glycol-solution fill requirements.
7. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Division 07 Section "Penetration Firestopping".
8. Piping in Exterior Pavement:
  - a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
  - b. Space cable ties a maximum of **18 inches (457 mm)** o.c., and at center of turns or bends.
  - c. Maintain **3-inch (75-mm)** minimum cover.
  - d. Install a sleeve of **3/8-inch- (9.5-mm-)** thick, foam-type insulation or PE pipe around tubing and extending for a minimum of **10 inches (250 mm)** on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
  - e. Maintain minimum **40-psig (275-kPa)** pressure in piping during concrete placement and continue for 24 hours after placement.
9. Piping in Interior Reinforced-Concrete Floors:
  - a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
  - b. Space cable ties a maximum of **18 inches (457 mm)** o.c., and at center of turns or bends.
  - c. Maintain **2-inch (50-mm)** minimum cover.
  - d. Install a sleeve of **3/8-inch- (9.5-mm-)** thick, foam-type insulation or PE pipe around tubing and extending for a minimum of **10 inches (250 mm)** on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
  - e. Maintain minimum **40-psig (275-kPa)** pressure in piping during concrete placement and continue for 24 hours after placement.
10. Piping in Level Fill Concrete Floors (Not Reinforced):
  - a. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
  - b. Space tracks, clamps, or staples a maximum of **18 inches (457 mm)** o.c., and at center of turns or bends.
  - c. Maintain **3/4-inch (19-mm)** minimum cover.
  - d. Install a sleeve of **3/8-inch- (9.5-mm-)** thick, foam-type insulation or PE pipe around tubing and extending for a minimum of **10 inches (250 mm)** on each side of slab joints to protect the tubing passing through expansion or control joints. Anchor sleeve to slab form at control joints to provide maximum clearance for saw cut.
  - e. Maintain minimum **40-psig (275-kPa)** pressure in piping during the concrete pour and continue for 24 hours during curing.
11. Piping in Ceiling:
  - a. Secure piping by attaching pipes to ceiling substrate using clamps or staples.
  - b. Space clamps or staples a maximum of **18 inches (457 mm)** o.c., and at center of turns or bends.
  - c. Maintain **1-1/2-inch (38-mm)** minimum plaster cover.
  - d. Maintain minimum **40-psig (275-kPa)** pressure in piping during the plaster application and continue for 24 hours during curing.
12. Piping in Subfloor:
  - a. Secure piping by laying piping in subfloor channels or modular interlocking blocks.
  - b. Use straight channel panels or blocks in the center, and curved channel panels or blocks at the ends.
  - c. Finish floor with mineralboard panel cover or finished floor surface.
13. Piping below Wood Floor:
  - a. Secure piping by attaching pipes to subfloor using heat-emission plates, clamps, or staples.

- b. Space heat-emission plates, clamps, or staples a maximum of **4 inches (100 mm)** o.c., and at center of turns or bends.
- c. Install heat-emission plates on underside of wood subfloor with maximum space between plates, as noted above, to maintain pipe contact with floor.
- 14. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved.
- 15. After system balancing has been completed, mark balancing valves to permanently indicate final position.
- 16. Perform the following adjustments before operating the system:
  - a. Open valves to fully open position.
  - b. Check operation of automatic valves.
  - c. Set temperature controls so all zones call for full flow.
  - d. Purge air from piping.
- 17. After the concrete or plaster heating panel has cured as recommended by concrete or plaster supplier, operate radiant heating system as follows:
  - a. Start system heating at a maximum of **10 deg F (6 deg C)** above the ambient radiant panel temperature, and increase **10 deg F (6 deg C)** each following day until design temperature is achieved.
  - b. For freeze protection, operate at a maximum of **60 deg F (16 deg C)** supply-water temperature.

C. Field Quality Control

- 1. Prepare radiant heating piping for testing as follows:
  - a. Open all isolation valves and close bypass valves.
  - b. Open and verify operation of zone control valves.
  - c. Flush with clean water, and clean strainers.
- 2. Tests and Inspections:
  - a. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than **100 psig (690 kPa)**. Repair leaks and retest until no leaks exist.
  - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- 3. Remove and replace malfunctioning radiant heating piping components that do not pass tests, and retest as specified above.
- 4. Prepare a written report of testing.

END OF SECTION 23 21 13 23a

Task	Specification	Specification Description
23 21 13 23	21 05 23 00	Piped Utilities Basic Materials And Methods
23 21 13 23	23 11 23 00	Relief Wells
23 21 13 23	13 12 13 00	Water Distribution
23 21 13 23	23 11 23 00a	Monitoring Wells
23 21 13 23	22 11 23 23	Water Supply Wells
23 21 13 23	22 05 76 00	Sanitary Sewerage
23 21 13 23	23 05 29 00	Steam Distribution
23 21 13 23	07 63 00 00	Common Work Results for Fire Suppression
23 21 13 23	07 63 00 00a	Common Work Results for Plumbing
23 21 13 23	07 63 00 00b	Common Work Results for HVAC
23 21 13 23	22 11 16 00	Domestic Water Piping
23 21 13 23	22 11 16 00a	Sanitary Waste And Vent Piping
23 21 13 23	22 11 16 00b	Storm Drainage Piping
23 21 13 23	22 11 16 00c	Hydronic Piping
23 21 13 23	22 11 16 00d	Steam And Condensate Piping
23 21 13 23	22 11 16 00e	Refrigerant Piping
23 21 13 23	23 11 23 00b	Facility Natural-Gas Piping
23 21 13 23	23 11 23 00c	Facility Liquefied-Petroleum Gas Piping
23 21 13 23	22 11 16 00f	General-Service Compressed-Air Piping
23 21 13 23	22 11 16 00g	Compressed-Air Piping For Laboratory And Healthcare Facilities
23 21 13 23	22 11 16 00h	Vacuum Piping For Laboratory And Healthcare Facilities
23 21 13 23	22 11 16 00i	Gas Piping For Laboratory And Healthcare Facilities
23 21 16 00	01 22 16 00	No Specification Required
23 21 16 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 21 16 00	13 12 13 00	Water Distribution
23 21 16 00	23 05 29 00	Steam Distribution
23 21 16 00	22 12 23 26	Underground Storage Tanks
23 21 16 00	07 63 00 00	Common Work Results for Fire Suppression
23 21 16 00	07 63 00 00a	Common Work Results for Plumbing
23 21 16 00	07 63 00 00b	Common Work Results for HVAC
23 21 16 00	22 11 16 00c	Hydronic Piping
23 21 16 00	22 11 16 00d	Steam And Condensate Piping
23 21 16 00	22 11 16 00e	Refrigerant Piping
23 21 16 00	22 11 23 23a	Hydronic Pumps
23 21 16 00	23 21 13 23	Facility Fuel-Oil Piping
23 21 16 00	22 11 16 00f	General-Service Compressed-Air Piping
23 21 16 00	22 11 19 00	Electronic Air Cleaners
23 21 23 13	21 05 23 00	Piped Utilities Basic Materials And Methods
23 21 23 13	22 11 23 23	Water Supply Wells
23 21 23 13	22 11 23 23a	Hydronic Pumps
23 21 23 16	21 05 23 00	Piped Utilities Basic Materials And Methods
23 21 23 16	22 11 23 23	Water Supply Wells
23 21 23 16	22 11 23 23a	Hydronic Pumps



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## SECTION 23 21 23 23 - ELECTRIC-DRIVE, VERTICAL-TURBINE FIRE PUMPS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for electric-drive, vertical-turbine fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Vertical-turbine fire pumps.
  - b. Fire-pump accessories and specialties.
  - c. Flowmeter systems.

#### C. Performance Requirements

1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: **175 psig (1200 kPa)** minimum unless higher pressure rating is indicated.

#### D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For fire pumps, motor drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

### 1.2 PRODUCTS

- A. General Requirements For Vertical-Turbine Fire Pumps
1. Description: Factory-assembled and -tested fire-pump and driver unit.
  2. Base: Fabricated and attached to fire-pump and driver unit with reinforcement to resist movement of pump during seismic events when base is anchored to building substrate.
  3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.
- B. Vertical-Turbine Fire Pumps
1. Pump Head: Cast iron, for surface discharge.
    - a. Discharge Outlet: With flange according to ASME B16.1 except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
    - b. Pump Head Seal: Stuffing box and packing.
    - c. Base: Cast iron or steel with hole for electrical cable.
  2. Pump:
    - a. Standard: UL 448, for vertical-turbine pumps for fire service.
    - b. Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
    - c. Line Shaft Bearings: Rubber sleeve, water lubricated.
    - d. Line Shaft: Steel.
    - e. Line Shaft Bearings: Corrosion resistant, oil lubricated.
    - f. Impeller Shaft: Monel metal or stainless steel.
    - g. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
    - h. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections **10 feet (3 m)** or less.
    - i. Suction Strainer: Cast or fabricated, bronze or stainless steel, and sized to restrict passage of **0.5-inch (12.7-mm)** spheres.
  3. Driver:
    - a. Standard: UL 1004A.
    - b. Type: Electric motor; NEMA MG 1, polyphase Design B.
    - c. Mounting: On pump head above pump.
- C. Fire-Pump Accessories And Specialties
1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.
  2. Relief Valves:
    - a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
  3. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.
  4. Discharge Cone: Closed **OR** Open, **as directed**, type.
  5. Hose Valve Manifold Assembly:
    - a. Standard: Comply with requirements in NFPA 20.
    - b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
    - c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
    - d. Automatic Drain Valve: UL 1726.
    - e. Manifold:
      - 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
      - 2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
      - 3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
      - 4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
      - 5) Escutcheon Plate: Brass or bronze; rectangular.
      - 6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.

7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.

8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

**OR**

Manifold:

1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.

2) Body: Exposed type, brass, with number of outlets required by NFPA 20.

3) Escutcheon Plate: Brass or bronze; round.

4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.

5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.

6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."

D. Flowmeter Systems

1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.

2. Pressure Rating: **175 psig (1200 kPa)** minimum **OR 250 psig (1725 kPa)**, **as directed**.

3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.

4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than **4-1/2 inches (115 mm)** in diameter. Include bracket or device for wall mounting.

a. Tubing Package: **NPS 1/8 or NPS 1/4 (DN 6 or DN 10)** soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.

**OR**

Portable Flowmeter: Compatible with flow sensor; with dial not less than **4-1/2 inches (115 mm)** in diameter and with two **12-foot- (3.7-m-)** long hoses in carrying case.

E. Grout

1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.

2. Characteristics: Nonshrink and recommended for interior and exterior applications.

3. Design Mix: **5000-psi (34-MPa)**, 28-day compressive strength.

4. Packaging: Premixed and factory packaged.

F. Source Quality Control

1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Protection Tests."

a. Verification of Performance: Rate fire pumps according to UL 448.

2. Fire pumps will be considered defective if they do not pass tests and inspections.

3. Prepare test and inspection reports.

1.3 EXECUTION

A. Installation

1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.

2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".

a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.

b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

- c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
  3. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.
  4. Support piping and pumps separately so weight of piping does not rest on pumps.
  5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
  6. Install pressure gage on pump head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
  7. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
  8. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical installer.
  9. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Alignment
1. Align pump and driver shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
  2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
  3. Align piping connection.
  4. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.
- C. Connections
1. Comply with requirements for piping and valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to pumps and equipment to allow service and maintenance.
  3. Connect relief-valve discharge to drainage piping or point of discharge.
  4. Connect flowmeter-system meters, sensors, and valves to tubing.
  5. Connect fire pumps to their controllers.
- D. Identification
1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.
- E. Field Quality Control
1. Test each fire pump with its controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Division 21 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps"
  2. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  3. Tests and Inspections:
    - a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
    - b. Test according to NFPA 20 for acceptance and performance testing.

- c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
    - d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 4. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
  - 5. Prepare test and inspection reports.
  - 6. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to the Owner.
- F. Startup Service
- 1. Perform startup service.
    - a. Complete installation and startup checks according to manufacturer's written instructions.
- G. Demonstration
- 1. Train the Owner's maintenance personnel to adjust, operate, and maintain fire pumps.

END OF SECTION 23 21 23 23



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## SECTION 23 21 23 23a - DIESEL-DRIVE, VERTICAL-TURBINE FIRE PUMPS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for diesel-drive, vertical-turbine fire pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Vertical-turbine fire pumps.
  - b. Fire-pump accessories and specialties.
  - c. Flowmeter systems.

#### C. Performance Requirements

1. Seismic Performance: Fire pumps shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Pump Equipment, Accessory, and Specialty Pressure Rating: **175 psig (1200 kPa)** minimum unless higher pressure rating is indicated.

#### D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, performance curves, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For fire pumps, right-angle gear drives, engine drivers, and fire-pump accessories and specialties. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For fire pumps, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
4. Product Certificates: For each fire pump, from manufacturer.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.
2. NFPA Compliance: Comply with NFPA 20, "Installation of Stationary Pumps for Fire Protection."

## 1.2 PRODUCTS

### A. General Requirements For Vertical-Turbine Fire Pumps

1. Description: Factory-assembled and -tested fire pump, right-angle gear drive, and driver.
2. Base: Fabricated and attached to fire pump, right-angle gear drive, and driver with reinforcement to resist movement of pump, gear drive, and driver during seismic events when base is anchored to building substrate.
3. Finish: Red paint applied to factory-assembled and -tested unit before shipping.

### B. Vertical-Turbine Fire Pumps

1. Pump Head: Cast iron, for surface discharge.
  - a. Discharge Outlet: With flange according to ASME B16.1 except connections may be threaded according to ASME B1.20.1, in sizes where flanges are not available.
  - b. Pump Head Seal: Stuffing box and packing.
  - c. Base: Cast iron or steel with hole for electrical cable.
2. Pump:
  - a. Standard: UL 448, for vertical-turbine pumps for fire service.
  - b. For static water levels of 50 feet (15 m) or less and for water-lubricated bearings.
    - 1) Line Shaft: Stainless steel or steel, with corrosion-resistant shaft sleeves.
    - 2) Line Shaft Bearings: Rubber sleeve, water lubricated.
  - c. For static water levels between 50 and 200 feet (15 and 61 m) and for oil-lubricated bearings.
    - 1) Line Shaft: Steel.
    - 2) Line Shaft Bearings: Corrosion resistant, oil lubricated.
  - d. Impeller Shaft: Monel metal or stainless steel.
  - e. Bowl Section: Multiple cast-iron bowls with closed-type bronze or stainless-steel impellers.
  - f. Column Pipe: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with threaded ends and cast-iron or steel fittings, in sections 10 feet (3 m) or less.
  - g. Suction Strainer: Cast or fabricated, bronze or stainless steel, and sized to restrict passage of 0.5-inch (12.7-mm) spheres.
3. Right-Angle Gear Drive:
  - a. Description: FM-Approved, speed-reduction gear drive for pump speed control. Provide ratio for outlet speed of approximately 1760 rpm.
4. Engine-to-Gear Drive Shaft: FM-Approved, telescoping, steel drive shaft with universal joint and grease fitting at each end. Include metal shaft guard.
5. Driver:
  - a. Standard: UL 1247.
  - b. Type: Diesel engine.
  - c. Emergency Manual Operator: Factory wired for starting and operating standby engine in case of malfunction in main controller or wiring.
  - d. Engine Cooling System: Factory-installed radiator.
    - 1) Coolant: Type recommended by driver manufacturer.

**OR**

Engine Cooling System: Factory-installed water piping, valves, strainer, pressure regulator, heat exchanger, coolant pump, bypass piping, and fittings.
  - 1) Piping: ASTM B 88, Type L (ASTM B 88M, Type B), copper water tube; ASME B16.22, wrought-copper, solder-joint pressure fittings; AWS A5.8/A5.8M, BCuP Series brazing filler metal; and brazed joints.
  - e. Engine-Jacket Water Heater: Factory-installed electric elements.
  - f. Dual Batteries: Lead-acid-storage type with 100 percent standby reserve capacity.
  - g. Fuel System: According to NFPA 20.
    - 1) Fuel Storage Tank: Size indicated but not less than required by NFPA 20. Include floor legs, direct-reading level gage, and secondary containment tank with capacity at least equal to fuel storage tank.

- h. Exhaust System: ASTM A 53/A 53M, Type E or S, Schedule 40, black steel pipe; ASME B16.9, weld-type pipe fittings; ASME B16.5, steel flanges; and ASME B16.21, nonmetallic gaskets. Fabricate double-wall, ventilated thimble from steel pipe.
    - 1) Exhaust Connector: Flexible type.
    - 2) Exhaust Silencer: Industrial **OR** Residential, **as directed**, type.
- C. Fire-Pump Accessories And Specialties
1. Automatic Air-Release Valves: Comply with NFPA 20 for installation in fire-pump discharge piping.
  2. Relief Valves:
    - a. Description: UL 1478, bronze or cast iron, spring loaded; for installation in fire-suppression water-supply piping.
  3. Outlet Fitting: Concentric tapered reducer at pump-head discharge outlet.
  4. Discharge Cone: Closed **OR** Open, **as directed**, type.
  5. Hose Valve Manifold Assembly:
    - a. Standard: Comply with requirements in NFPA 20.
    - b. Header Pipe: ASTM A 53/A 53M, Schedule 40, galvanized steel with ends threaded according to ASME B1.20.1.
    - c. Header Pipe Fittings: ASME B16.4, galvanized cast-iron threaded fittings.
    - d. Automatic Drain Valve: UL 1726.
    - e. Manifold:
      - 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
      - 2) Body: Flush type, brass or ductile iron, with number of outlets required by NFPA 20.
      - 3) Nipples: ASTM A 53/A 53M, Schedule 40, galvanized-steel pipe with ends threaded according to ASME B1.20.1.
      - 4) Adapters and Caps with Chain: Brass or bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
      - 5) Escutcheon Plate: Brass or bronze; rectangular.
      - 6) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads.
      - 7) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
      - 8) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."
- OR**
- e. Manifold:
    - 1) Test Connections: Comply with UL 405 except provide outlets without clappers instead of inlets.
    - 2) Body: Exposed type, brass, with number of outlets required by NFPA 20.
    - 3) Escutcheon Plate: Brass or bronze; round.
    - 4) Hose Valves: UL 668, bronze, with outlet threaded according to NFPA 1963 and matching local fire-department threads. Include caps and chains.
    - 5) Exposed Parts Finish: Polished **OR** Rough, **as directed**, brass, **as directed**, chrome plated, **as directed**.
    - 6) Escutcheon Plate Marking: Equivalent to "FIRE PUMP TEST."
- D. Flowmeter Systems
1. Description: UL-listed or FM-Approved, fire-pump flowmeter system with capability to indicate flow to not less than 175 percent of fire-pump rated capacity.
  2. Pressure Rating: **175 psig (1200 kPa)** minimum **OR 250 psig (1725 kPa)**, **as directed**.
  3. Sensor: Annubar probe, orifice plate, or venturi unless otherwise indicated. Sensor size shall match pipe, tubing, flowmeter, and fittings.
  4. Permanently Mounted Flowmeter: Compatible with flow sensor; with dial not less than **4-1/2 inches (115 mm)** in diameter. Include bracket or device for wall mounting.
    - a. Tubing Package: **NPS 1/8 or NPS 1/4 (DN 6 or DN 10)** soft copper **OR** plastic, **as directed**, tubing with copper or brass fittings and valves.

**OR**

Portable Flowmeter: Compatible with flow sensor; with dial not less than **4-1/2 inches (115 mm)** in diameter and with two **12-foot- (3.7-m-)** long hoses in carrying case.

**E. Grout**

1. Standard: ASTM C 1107, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
2. Characteristics: Nonshrink and recommended for interior and exterior applications.
3. Design Mix: **5000-psi (34-MPa)**, 28-day compressive strength.
4. Packaging: Premixed and factory packaged.

**F. Source Quality Control**

1. Testing: Test and inspect fire pumps according to UL 448 requirements for "Operation Test" and "Manufacturing and Production Tests."
  - a. Verification of Performance: Rate fire pumps according to UL 448.
2. Fire pumps will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

**1.3 EXECUTION****A. Installation**

1. Fire-Pump Installation Standard: Comply with NFPA 20 for installation of fire pumps, relief valves, and related components.
2. Equipment Mounting: Install fire pumps on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install fire-pump discharge piping equal to or larger than size required by NFPA 20.
4. Support piping and pumps separately so weight of piping does not rest on pumps.
5. Install valves that are same size as connecting piping. Comply with requirements for fire-protection valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
6. Install pressure gage on pump head discharge flange pressure-gage tapping. Comply with requirements for pressure gages specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**.
7. Install piping hangers and supports, anchors, valves, gages, and equipment supports according to NFPA 20.
8. Install fuel system according to NFPA 20.
9. Install water supply and drain piping for diesel-engine heat exchangers. Extend drain piping from heat exchangers to point of disposal.
10. Install exhaust system piping for diesel engines. Extend to point of termination outside structure. Install pipe and fittings with welded joints; install components having flanged connections with gasketed joints.
11. Install condensate drain piping for diesel-engine exhaust system. Extend drain piping from low points of exhaust system to condensate traps and to point of disposal.
12. Install flowmeters and sensors. Install flowmeter-system components and make connections according to NFPA 20 and manufacturer's written instructions.
13. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not factory mounted. Furnish copies of manufacturers' wiring diagram submittals to electrical Installer.

14. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- B. Alignment
  1. Align fire-pump-driver, right-angle gear-drive, and fire-pump shafts after complete unit has been leveled on concrete base, grout has set, and anchor bolts have been tightened.
  2. After alignment is correct, tighten anchor bolts evenly. Fill baseplate completely with grout, with metal blocks and shims or wedges in place. Tighten anchor bolts after grout has hardened. Check alignment and make required corrections.
  3. Align piping connections.
  4. Align pump and driver shafts for angular and parallel alignment according to HI 2.4 and to tolerances specified by manufacturer.
- C. Connections
  1. Comply with requirements for piping and valves specified in Division 21 Section(s) "Fire-suppression Standpipes" OR "Wet-pipe Sprinkler Systems", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to pumps and equipment to allow service and maintenance.
  3. Connect relief-valve discharge to drainage piping or point of discharge.
  4. Connect flowmeter-system meters, sensors, and valves to tubing.
  5. Connect fire pumps to their controllers.
- D. Identification
  1. Identify system components. Comply with requirements for fire-pump marking according to NFPA 20.
- E. Field Quality Control
  1. Test each fire pump with its right-angle gear drive and controller as a unit. Comply with requirements for electric-motor-driver fire-pump controllers specified in Division 21 Section(s) "Electric-drive, Centrifugal Fire Pumps" OR "Diesel-drive, Centrifugal Fire Pumps" OR "Electric-drive, Vertical-turbine Fire Pumps" OR "Diesel-drive, Vertical-turbine Fire Pumps".
  2. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  3. Tests and Inspections:
    - a. After installing components, assemblies, and equipment including controller, test for compliance with requirements.
    - b. Test according to NFPA 20 for acceptance and performance testing.
    - c. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
    - d. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  4. Components, assemblies, and equipment will be considered defective if they do not pass tests and inspections.
  5. Prepare test and inspection reports.
  6. Furnish fire hoses in number, size, and length required to reach storm drain or other acceptable location to dispose of fire-pump test water. Hoses are for tests only and do not convey to the Owner.
- F. Startup Service
  1. Perform startup service.
    - a. Complete installation and startup checks according to manufacturer's written instructions.





- G. Demonstration
  - 1. Train the Owner's maintenance personnel to adjust, operate, and maintain fire pumps, right-angle gear drives, and fire-pump controllers.

END OF SECTION 23 21 23 23a

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Task	Specification	Specification Description
23 21 23 23	21 05 23 00	Piped Utilities Basic Materials And Methods
23 21 23 23	22 11 23 23	Water Supply Wells
23 21 29 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 21 29 00	22 11 23 23a	Hydronic Pumps
23 22 16 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 22 16 00	13 12 13 00	Water Distribution
23 22 16 00	23 05 29 00	Steam Distribution
23 22 16 00	21 05 19 00	Meters and Gages for Plumbing Piping
23 22 16 00	21 05 19 00a	Meters and Gages for HVAC Piping
23 22 16 00	22 11 16 00d	Steam And Condensate Piping
23 22 16 00	22 11 16 00e	Refrigerant Piping
23 22 16 00	22 11 16 00f	General-Service Compressed-Air Piping

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## SECTION 23 22 23 13 - STEAM CONDENSATE PUMPS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for steam condensate pumps. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes electric-driven and pressure-powered steam condensate pumps.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include details of installation.
  - a. Include wiring diagrams.
3. Operation and maintenance data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label steam condensate pumps to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.

#### E. Delivery, Storage, and Handling

1. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
2. Store steam condensate pumps in dry location.
3. Retain protective covers for flanges and protective coatings during storage.
4. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
5. Comply with pump manufacturer's written rigging instructions.

### 1.2 PRODUCTS

#### A. Electric-Driven Steam Condensate Pumps

1. Description: Factory-fabricated, packaged, electric-driven pumps; with receiver, pump(s), controls, and accessories suitable for operation with steam condensate.
2. Configuration: Simplex **OR** Duplex, **as directed**, floor-mounting pump with receiver and float switch(es); rated to pump **200 deg F (93 deg C)** steam condensate.
  - a. Receiver: Floor-mounting, close-grained cast iron **OR** welded steel, **as directed**; with externally adjustable float switch(es), and flange(s) for pump mounting.
  - b. Pump(s): Centrifugal, close coupled, vertical design, permanently aligned, and bronze fitted; with replaceable bronze case ring and mechanical seal; mounted on receiver flange.
  - c. Factory Wiring: Between pump(s) and float switch(es), for single external electrical connection. Fused control power transformer if voltage exceeds 230 V.
  - d. Electrical **OR** Mechanical, **as directed**, pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate if the normal start level for a single pump is exceeded.
3. Configuration: Duplex floor-mounting pump with receiver and float switches; rated to pump **210 deg F (99 deg C)** steam condensate.



- a. Receiver: Floor-mounting, close-grained cast iron **OR** welded steel, **as directed**; with externally adjustable float switches and flanges for pump mounting.
  - b. Pumps: Regenerative turbine, close coupled, permanently aligned, and bronze fitted; with mechanical seals and an independent pump control circuit for each pump; mounted on base or receiver flange; rated to operate with a minimum of **2 feet (6 kPa)** of NPSH.
  - c. Factory Wiring: Between pumps and float switches, for single external electrical connection. Fused control power transformer if voltage exceeds 230 V.
  - d. Electrical **OR** Mechanical, **as directed**, pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate if the normal start level for a single pump is exceeded.
4. Configuration: Duplex floor-mounting pumps with receiver and float switches; rated to pump minimum **200 deg F (93 deg C) OR 210 deg F (99 deg C)**, **as directed**, steam condensate.
- a. Receiver: Floor-mounting, close-grained cast iron **OR** welded steel, **as directed**; externally adjustable float switches; with water-level gage, steam condensate thermometer, discharge-pressure gage for each pump, bronze gate valves between receiver and pumps, flanges for pump mounting, and lifting eyebolts.
  - b. Inlet Strainer: Cast iron with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.
  - c. Pumps: Centrifugal, close coupled, vertical design, permanently aligned, and bronze fitted; with replaceable bronze case rings, stainless-steel shafts, and mechanical seals; mounted on receiver flanges; rated to operate with a minimum of **2 feet (6 kPa)** of NPSH.
  - d. Control Panel: NEMA 250, Type 1 **OR** 2 **OR** 12, **as directed**, enclosure with hinged door and grounding lug, mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
    - 1) Motor controller for each pump.
    - 2) Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
    - 3) Manual lead-lag control to override electrical pump alternator to manually select the lead pump.
    - 4) Momentary contact "TEST" push button on cover for each pump.
    - 5) Numbered terminal strip.
    - 6) Disconnect switch.
    - 7) Fused transformer for control circuit.
5. Configuration: Duplex floor-mounting pump with elevated receiver, float switches, and connecting piping; rated to pump **212 deg F (100 deg C)** steam condensate.
- a. Receiver: Close-grained cast iron **OR** Welded steel, **as directed**, mounted on fabricated-steel supports; externally adjustable float switches; with water-level gage, steam condensate thermometer, pump discharge pressure gages, bronze isolation valves between receiver and pumps, and lifting eyebolts.
  - b. Inlet Strainer: Cast iron with self-cleaning bronze screen, dirt pocket, and cleanout plug on receiver inlet.
  - c. Pumps: Centrifugal, close coupled, permanently aligned, and bronze fitted; with replaceable bronze case rings, stainless-steel shafts, and mechanical seals; mounted on base below receiver; rated to operate with a minimum of **2 feet (6 kPa)** of NPSH.
  - d. Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106; Schedule 80; seamless steel.
  - e. Fittings **NPS 2 (DN 50)** and Smaller: ASME B16.1, Class 125 cast iron, threaded.
  - f. Fittings **NPS 2-1/2 (DN 65)** and Larger: ASTM A 234/A 234M, steel, for welded connections.
  - g. Control Panel: NEMA 250, Type 1 **OR** 2 **OR** 12, **as directed**, enclosure with hinged door and grounding lug; mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
    - 1) Motor controller for each pump.
    - 2) Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.

- 3) Manual lead-lag control to override electrical alternator to manually select the lead pump.
- 4) Momentary contact "TEST" push button on cover for each pump.
- 5) Numbered terminal strip.
- 6) Disconnect switch.
- 7) Fused transformer for control circuit.
6. Configuration: Underground duplex pump with basin and float switches; rated to pump **200 deg F (93 deg C)** steam condensate.
  - a. Basin: Cast iron, with hub-type inlets.
  - b. Basin Cover: Cast iron or steel with gasketed openings for access, pumps, pump shafts, control rods, discharge piping, and vent connections.
    - 1) Anchor Flange: Cast iron, attached to basin, in location and of size required to anchor basin to concrete slab.
  - c. Pumps: Wet-pit mounted, vertical, flexible coupled, and suspended.
    - 1) Casing: Cast iron with open inlet.
    - 2) Shaft and Bearings: Stainless-steel shaft with oil-lubricated, bronze, intermediate sleeve bearings; **48-inch (1200-mm)** maximum intervals where basin depth is more than **48 inches (1200 mm)**; and grease-lubricated, ball-type, thrust bearings.
    - 3) Shaft Couplings: Flexible, capable of absorbing vibration.
    - 4) Seals: Mechanical; with carbon rotating ring, bearing on a ceramic seat held by a stainless-steel spring, and enclosed by a flexible bellows and gasket.
    - 5) Motors: Vertically mounted on cast-iron pedestal.
    - 6) Pump Discharge Piping: Manufacturer's standard steel or bronze pipe, unless otherwise indicated.
  - d. Control Panel: NEMA 250, Type 1 **OR 2 OR 12, as directed**, enclosure with hinged door and grounding lug; mounted on pump; factory wired for single external electrical connection; and with the following components within cabinet:
    - 1) Motor controller for each pump.
    - 2) Electrical pump alternator to operate pumps in lead-lag sequence and allow both pumps to operate on receiver high level.
    - 3) Manual lead-lag control to override electrical alternator to manually select the lead pump.
    - 4) Momentary contact "TEST" push button on cover for each pump.
    - 5) Numbered terminal strip.
    - 6) Disconnect switch.
    - 7) Fused transformer for control circuit.
- B. Pressure-Powered Steam Condensate Pumps
  1. Description: Factory-fabricated, pressure-powered pumps with mechanical controls, valves, piping connections, and accessories suitable for pumping steam condensate using steam **OR** compressed air, **as directed**.
  2. Configuration: Simplex **OR** Duplex, **as directed**, pump with float-operated valve control.
    - a. Pump Body: Cast iron **OR** Welded steel, **as directed**.
    - b. Piping Connections: Threaded; for steam condensate, operating medium, vent, and indicated accessories.
    - c. Level Gage: Glass site gage with shutoff cocks.
    - d. Valves: Manufacturer's standard check valves on inlet and outlet.
    - e. Internal Parts: Stainless-steel float, springs, and actuating mechanism.
    - f. Valve Seals: Replaceable from exterior.
    - g. Receiver: Cast iron **OR** Welded steel, **as directed**, factory mounted on steel supports; with water-level site glass and threaded piping connections.
    - h. Pipe: ASTM A 53/A 53M, Type S, Grade B or ASTM A 106; Schedule 80; seamless steel.
    - i. Fittings: ASME B16.1, Class 125 cast iron, threaded.

C. Motors



1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

### 1.3 EXECUTION

#### A. Installation

1. Install pumps according to HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."
2. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
3. Support pumps and piping separately so piping is not supported by pumps.
4. Install pumps on concrete bases. Anchor pumps to bases using inserts or anchor bolts.
5. Install thermometers and pressure gages.

#### B. Connections

1. Install piping adjacent to machine to allow service and maintenance.
2. Install steam supply for pressure-powered pumps as required by Division 23 Section "Steam And Condensate Heating Piping".
3. Install compressed-air supply for pressure-powered pumps as required by Division 22 Section "General-service Compressed-air Piping".
4. Install gate and check valves on inlet and outlet of pressure-powered pumps.
5. Install check valve, gate valve, and globe valve at pump discharge connections for each electric-driven pump.
6. Pipe drain to nearest floor drain for overflow and drain piping connections.
7. Install full-size vent piping to outdoors, terminating in 180-degree elbow at point above highest steam system connection or as indicated.
8. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

END OF SECTION 23 22 23 13



Task	Specification	Specification Description
23 23 13 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 23 13 00	22 11 16 00e	Refrigerant Piping
23 23 16 00	07 63 00 00	Common Work Results for Fire Suppression
23 23 16 00	07 63 00 00a	Common Work Results for Plumbing
23 23 16 00	07 63 00 00b	Common Work Results for HVAC
23 23 16 00	22 11 16 00a	Sanitary Waste And Vent Piping
23 23 16 00	22 11 16 00b	Storm Drainage Piping
23 23 16 00	22 11 16 00c	Hydronic Piping
23 23 16 00	22 11 16 00e	Refrigerant Piping
23 23 16 00	23 01 60 71	Condensing Units
23 23 23 00	23 01 60 71	Condensing Units

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## SECTION 23 25 13 00 - HVAC WATER TREATMENT

### A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC water treatment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the products manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work

### B. Summary

1. This Section includes the following HVAC water-treatment systems:
  - a. Bypass chemical-feed equipment and controls.
  - b. Biocide chemical-feed equipment and controls.
  - c. Ozone-generator biocide equipment and controls.
  - d. UV-irradiation unit, biocide equipment, and controls.
  - e. Chemical treatment test equipment.
  - f. HVAC water-treatment chemicals.
  - g. Makeup water softeners.
  - h. RO equipment for HVAC makeup water.
  - i. Water filtration units for HVAC makeup water.

### C. Definitions

1. EEPROM: Electrically erasable, programmable read-only memory.
2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
3. RO: Reverse osmosis.
4. TDS: Total dissolved solids.
5. UV: Ultraviolet.

### D. Performance Requirements

1. Water quality for HVAC systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of HVAC equipment without creating a hazard to operating personnel or the environment.
2. Base HVAC water treatment on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
3. Closed hydronic systems, including hot-water heating, chilled water, dual-temperature water, and glycol cooling, shall have the following water qualities:
  - a. pH: Maintain a value within 9.0 to 10.5.
  - b. "P" Alkalinity: Maintain a value within 100 to 500 ppm.
  - c. Boron: Maintain a value within 100 to 200 ppm.
  - d. Chemical Oxygen Demand: Maintain a maximum value of 100 ppm.
  - e. Soluble Copper: Maintain a maximum value of 0.20 ppm.
  - f. TDS: Maintain a maximum value of 10 ppm.
  - g. Ammonia: Maintain a maximum value of 20 ppm.
  - h. Free Caustic Alkalinity: Maintain a maximum value of 20 ppm.
  - i. Microbiological Limits:
    - 1) Total Aerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
    - 2) Total Anaerobic Plate Count: Maintain a maximum value of 100 organisms/ml.
    - 3) Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
    - 4) Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
    - 5) Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
4. Steam Boiler and Steam Condensate:
  - a. Steam Condensate:
    - 1) pH: Maintain a value within 7.8 to 8.4.
    - 2) Total Alkalinity: Maintain a value within 5 to 50 ppm.

- 3) Chemical Oxygen Demand: Maintain a maximum value of 15 ppm.
- 4) Soluble Copper: Maintain a maximum value of 0.20 ppm.
- 5) TDS: Maintain a maximum value of 10 ppm.
- 6) Ammonia: Maintain a maximum value of 20 ppm.
- 7) Total Hardness: Maintain a maximum value of 2 ppm.
- b. Steam boiler operating at **15 psig (104 kPa)** and less shall have the following water qualities:
  - 1) "OH" Alkalinity: Maintain a value within 200 to 400 ppm.
  - 2) TDS: Maintain a value within 600 to 3000 ppm.
- c. Steam boiler operating at more than **15 psig (104 kPa)** shall have the following water qualities:
  - 1) "OH" Alkalinity: 200 to 400 ppm.
  - 2) TDS: Maintain a value within 600 to 1200 ppm to maximum 30 times RO water TDS.
5. Open hydronic systems, including condenser **OR** fluid-cooler spray, **as directed**, water, shall have the following water qualities:
  - a. pH: Maintain a value within 8.0 to 9.1.
  - b. "P" Alkalinity: Maintain a maximum value of 100 ppm.
  - c. Chemical Oxygen Demand: Maintain a maximum value of 100ppm.
  - d. Soluble Copper: Maintain a maximum value of 0.20 ppm.
  - e. TDS: Maintain a maximum value of 10 ppm.
  - f. Ammonia: Maintain a maximum value of 20 ppm.
  - g. Free "OH" Alkalinity: Maintain a maximum value of 0 ppm.
  - h. Microbiological Limits:
    - 1) Total Aerobic Plate Count: Maintain a maximum value of 10,000 organisms/ml.
    - 2) Total Anaerobic Plate Count: Maintain a maximum value of 1000 organisms/ml.
    - 3) Nitrate Reducers: Maintain a maximum value of 100 organisms/ml.
    - 4) Sulfate Reducers: Maintain a maximum value of 0 organisms/ml.
    - 5) Iron Bacteria: Maintain a maximum value of 0 organisms/ml.
  - i. Polymer Testable: Maintain a minimum value within 10 to 40.
6. Passivation for Galvanized Steel: For the first 60 days of operation.
  - a. pH: Maintain a value within 7 to 8.
  - b. Calcium Carbonate Hardness: Maintain a value within 100 to 300 ppm.
  - c. Calcium Carbonate Alkalinity: Maintain a value within 100 to 300 ppm.

#### E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Pretreatment and chemical treatment equipment showing tanks, maintenance space required, and piping connections to HVAC systems. Include plans, elevations, sections, details, and attachments to other work.
  - a. Wiring Diagrams: Power and control wiring.
3. Field quality-control test reports.
4. Manufacturer Seismic Qualification Certification
5. Other Informational Submittals:
  - a. Water-Treatment Program: Written sequence of operation on an annual basis for the application equipment required to achieve water quality defined in the "Performance Requirements" Article above.
  - b. Water Analysis: Illustrate water quality available at Project site.
  - c. Passivation Confirmation Report: Verify passivation of galvanized-steel surfaces, and confirm this observation in a letter to the Owner.

#### F. Quality Assurance

1. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

## 1.2 PRODUCTS

### A. Manual Chemical-Feed Equipment

1. Bypass Feeders: Steel, with corrosion-resistant exterior coating, minimum **3-1/2-inch (89-mm)** fill opening in the top, and **NPS 3/4 (DN 20)** bottom inlet and top side outlet. Quarter turn or threaded fill cap with gasket seal and diaphragm to lock the top on the feeder when exposed to system pressure in the vessel.
  - a. Capacity: **2 gal. (7.6 L) OR 5 gal. (19 L), as directed.**
  - b. Minimum Working Pressure: **125 psig (860 kPa) OR 175 psig (1210 kPa), as directed.**

### B. Automatic Chemical-Feed Equipment

1. Water Meter:
  - a. AWWA C700, oscillating-piston, magnetic-drive, totalization meter.
  - b. Body: Bronze.
  - c. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa).**
  - d. Registration: **Gallons (Liters) or cubic feet (cubic meters).**
  - e. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
2. Water Meter:
  - a. AWWA C701, turbine-type, totalization meter.
  - b. Body: Bronze.
  - c. Minimum Working-Pressure Rating: **100 psig (690 kPa).**
  - d. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa).**
  - e. Registration: **Gallons (Liters) or cubic feet (cubic meters).**
  - f. End Connections: Threaded.
  - g. Control: Low-voltage signal capable of transmitting **1000 feet (305 m).**
3. Water Meter:
4. AWWA C701, turbine-type, totalization meter.
  - a. Body: Bronze **OR** Epoxy-coated cast iron, **as directed.**
  - b. Minimum Working-Pressure Rating: **150 psig (1035 kPa).**
  - c. Maximum Pressure Loss at Design Flow: **3 psig (20 kPa).**
  - d. Registration: **Gallons (Liters) or cubic feet (cubic meters).**
  - e. End Connections: Flanged.
  - f. Controls: Flow-control switch with normally open contacts; rated for maximum 10 A, 250-V ac; and that will close at adjustable increments of total flow.
5. Inhibitor Injection Timers:
  - a. Microprocessor-based controller with LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
  - b. Programmable timers with infinite adjustment over full range, and mounted in cabinet with hand-off-auto switches and status lights.
  - c. Test switch.
  - d. Hand-off-auto switch for chemical pump.
  - e. Illuminated legend to indicate feed when pump is activated.
  - f. Programmable lockout timer with indicator light. Lockout timer to deactivate the pump and activate alarm circuits.
  - g. LCD makeup totalizer to measure amount of makeup and bleed-off water from two water meter inputs.
6. pH Controller:

- a. Microprocessor-based controller, 1 percent accuracy in a range from zero to 14 units. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
  - b. Digital display and touch pad for input.
  - c. Sensor probe adaptable to sample stream manifold.
  - d. High, low, and normal pH indication.
  - e. High or low pH alarm light, trip points field adjustable; with silence switch.
  - f. Hand-off-auto switch for acid pump.
  - g. Internal adjustable hysteresis or deadband.
7. TDS Controller:
  - a. Microprocessor-based controller, 1 percent accuracy in a range from zero to 5000 micromhos. Incorporate solid-state integrated circuits and digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
  - b. Digital display and touch pad for input.
  - c. Sensor probe adaptable to sample stream manifold.
  - d. High, low, and normal conductance indication.
  - e. High or low conductance alarm light, trip points field adjustable; with silence switch.
  - f. Hand-off-auto switch for solenoid bleed-off valve.
  - g. Bleed-off valve activated indication.
  - h. Internal adjustable hysteresis or deadband.
  - i. Bleed Valves:
    - 1) Cooling Systems: Forged-brass body, globe pattern, general-purpose solenoid with continuous-duty coil, or motorized valve.
    - 2) Steam Boilers: Motorized ball valve, steel body, and TFE seats and seals.
8. Biocide Feeder Timer:
  - a. Microprocessor-based controller with digital LCD display in NEMA 250, Type 12 enclosure with gasketed and lockable door. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
  - b. 24-hour timer with 14-day skip feature to permit activation any hour of day.
  - c. Precision, solid-state, bleed-off lockout timer and clock-controlled biocide pump timer. Prebleed and bleed lockout timers.
  - d. Solid-state alternator to enable use of two different formulations.
  - e. 24-hour display of time of day.
  - f. 14-day display of day of week.
  - g. Battery backup so clock is not disturbed by power outages.
  - h. Hand-off-auto switches for biocide pumps.
  - i. Biocide A and Biocide B pump running indication.
9. Chemical Solution Tanks:
  - a. Chemical-resistant reservoirs fabricated from high-density opaque polyethylene with minimum 110 percent containment vessel.
  - b. Molded cover with recess for mounting pump.
  - c. Capacity: **30 gal. (114 L) OR 50 gal. (189 L) OR 120 gal. (454 L), as directed.**
10. Chemical Solution Injection Pumps:
  - a. Self-priming, positive-displacement; rated for intended chemical with minimum 25 percent safety factor for design pressure and temperature.
  - b. Adjustable flow rate.
  - c. Metal and thermoplastic construction.
  - d. Built-in relief valve.
  - e. Fully enclosed, continuous-duty, single-phase motor. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".



11. Chemical Solution Tubing: Polyethylene tubing with compression fittings and joints except ASTM A 269, Type 304, stainless steel for steam boiler injection assemblies.
  12. Injection Assembly:
    - a. Quill: Minimum **NPS 1/2 (DN 15)** with insertion length sufficient to discharge into at least 25 percent of pipe diameter.
    - b. Ball Valve: Three **OR** Two, **as directed**, -piece, stainless steel; selected to fit quill.
    - c. Packing Gland: Mechanical seal on quill of sufficient length to allow quill removal during system operation.
    - d. Assembly Pressure/Temperature Rating: Minimum **600 psig (4137 kPa)** at **200 deg F (93 deg C)**.
- C. Ozone-Generator Biocide Equipment
1. Corona discharge generator with stainless-steel generating cells, and transformer housed in a NEMA 250, Type 4 enclosure. Assembly shall be suitable for continuous duty. Provide site glasses to verify proper operation of generator.
  2. Water-cooled generators shall be provided with cooling water at maximum **70 deg F (21 deg C)** and **35 psig (241 kPa)**.
  3. Generator vessels exposed to system pressure shall be constructed according to ASME Boiler and Pressure Vessel Code and be equipped with pressure relief valve.
  4. External air compressor or induced airflow through a cleanable prefilter supplies concentrated oxygen through a molecular sieve with **minus 62 deg F (minus 52 deg C)** dew point to avoid the formation of nitric acid.
  5. Microprocessor-based control with software in EEPROM, surge protection, high-temperature cutout, and operational status lights. Interface for start/stop and status indication at central workstation as described in Division 23 Section "Instrumentation And Control For Hvac".
  6. Ozone Contactors:
    - a. Bubble diffusers.
    - b. Induction injection nozzle.
    - c. Injectors with static mixers.
  7. Ozone Detector and Alarm Devices:
    - a. Detector:
      - 1) Sensor: Metal dioxide semiconductor.
      - 2) Concentration Range: 0.01 to 0.14 ppm.
      - 3) Accuracy: Plus or minus 20 percent of range.
      - 4) Sensitivity: 0.01 ppm.
      - 5) Response Time: Maximum 10 seconds.
      - 6) Operating Temperature: **50 to 100 deg F (10 to 38 deg C)**.
      - 7) Relatively Humidity: 20 to 95 percent, noncondensing over the operating temperature range.
    - b. Horns:
      - 1) Electric-vibrating-polarized type.
      - 2) 24-V dc; with provision for housing the operating mechanism behind a grille.
      - 3) Horns shall produce a sound-pressure level of 90 dBA, measured **10 feet (3 m)** from the horn.
    - c. Visible Alarm Devices:
      - 1) Xenon strobe lights listed in UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate.
      - 2) Rated Light Output: **75 OR 110, as directed**, candela.
      - 3) Strobe Leads: Factory connected to screw terminals.
  8. Self-Contained Breathing Apparatus: Open-circuit, pressure-demand, compressed air includes completely assembled, portable, self-contained devices designed for hazardous breathing environment application.
    - a. Face Piece: EPDM or silicone rubber construction material, one-size-fits-all with double-sealing edge, stainless-steel speaking diaphragm and lens retainer, five adjustable straps to hold face piece to head (two straps on each side and one on top), exhalation valve in

mask, close-fitting nose piece to ensure no CO<sub>2</sub> buildup, and perspiration drain to avoid skin irritation and to prevent eyepiece, spectacle, and lens fogging.

- b. Backplate: Orthopedically designed of chemical and impact-resistant, glass-fiber composite **OR** aluminum, **as directed**.
- c. Harness and Carrier Assembly: Large triangular back pad, backplate, and adjustable waist and shoulder straps. Modular in design, detachable components, and easy to clean and maintain. Shoulder straps padded with flame-resistant material, reinforced with stainless-steel cable, and attached with T-nuts, washers, and screws.
- d. Air Cylinder: 30 **OR** 45 **OR** 60, **as directed**, -minute, low-pressure, air-supply-loaded fiberglass **OR** aluminum **OR** steel, **as directed**, cylinders fitted with quick-fill assembly for refilling and air transfer.
- e. Wall-Mounting Cabinet: Leakproof, corrosion-resistant, clear, plastic case.
- f. Tested and Certified: By the National Institute for Occupational Safety and Health and by the Mine Safety and Health Administration, according to 42 CFR 84, Subpart H.

#### D. Stainless-Steel Pipes And Fittings

- 1. Stainless-Steel Tubing: Comply with ASTM A 269, Type 316.
- 2. Stainless-Steel Fittings: Complying with ASTM A 815/A 815M, Type 316, Grade WP-S.
- 3. Two-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, carbon-filled TFE seats, threaded body design with adjustable stem packing, threaded ends, and **250-psig (1725-kPa)** SWP and **600-psig (4140-kPa)** CWP ratings.
- 4. Three-Piece, Full-Port, Stainless-Steel Ball Valves: ASTM A 351, Type 316 stainless-steel body; ASTM A 276, Type 316 stainless-steel stem and vented ball, threaded body design with adjustable stem packing, threaded ends, and **150-psig (1035-kPa)** SWP and **600-psig (4140-kPa)** CWP rating.

#### E. UV Biocide Equipment

- 1. Target Irradiation: Minimum 30,000 microwatts x s/sq. cm.
- 2. Light Source Vessels:
  - a. ASTM A 666, Type 304 stainless steel.
  - b. Construct for minimum **150 psig (1035 kPa)** at **150 deg F (65 deg C)** according to ASME Boiler and Pressure Vessel Code, and equipped with pressure relief valve.
  - c. Light Source Sleeve: Quartz, with EPDM O-ring seals.
  - d. Light Source: Replaceable UV lamp producing minimum target irradiation of 254-nm wavelength light.
- 3. Controls: Interlock with pumps to operate when water is circulating.

#### F. Chemical Treatment Test Equipment

- 1. Test Kit: Manufacturer-recommended equipment and chemicals in a wall-mounting cabinet for testing pH, TDS, inhibitor, chloride, alkalinity, and hardness; sulfite and testable polymer tests for high-pressure boilers, and oxidizing biocide test for open cooling systems.
- 2. Sample Cooler:
  - a. Tube: Sample.
    - 1) Size: **NPS 1/4 (DN 8)** tubing.
    - 2) Material: ASTM A 666, Type 316 stainless steel.
    - 3) Pressure Rating: Minimum **2000 psig (13 790 kPa)**.
    - 4) Temperature Rating: Minimum **850 deg F (454 deg C)**.
  - b. Shell: Cooling water.
    - 1) Material: ASTM A 666, Type 304 stainless steel.
    - 2) Pressure Rating: Minimum **250 psig (1725 kPa)**.
    - 3) Temperature Rating: Minimum **450 deg F (232 deg C)**.
  - c. Capacities and Characteristics:
    - 1) Tube: Sample.
      - a) Flow Rate: **0.25 gpm (0.016 L/s)**.

- b) Entering Temperature: 400 deg F (204 deg C).
      - c) Leaving Temperature: 88 deg F (31 deg C).
      - d) Pressure Loss: 6.5 psig (44.8 kPa).
    - 2) Shell: Cooling water.
      - a) Flow Rate: 3 gpm (0.19 L/s).
      - b) Entering Temperature: 70 deg F (21 deg C).
      - c) Pressure Loss: 1.0 psig (6.89 kPa).
  3. Corrosion Test-Coupon Assembly: Constructed of corrosive-resistant material, complete with piping, valves, and mild steel and copper coupons. Locate copper coupon downstream from mild steel coupon in the test-coupon assembly.
    - a. Two-station rack for closed-loop systems.
    - b. Four-station rack for open systems.
- G. Chemicals
1. Chemicals shall be as recommended by water-treatment system manufacturer that are compatible with piping system components and connected equipment, and that can attain water quality specified in Part 1.1 "Performance Requirements" Article.
  2. Water Softener Chemicals:
    - a. Mineral: High-capacity, sulfonated-polystyrene ion-exchange resin that is stable over entire pH range with good resistance to bead fracture from attrition or shock. Resin exchange capacity minimum 30,000 grains/cu. ft. (69 kg/cu. m) of calcium carbonate of resin when regenerated with 15 lb (6.8 kg) of salt.
    - b. Salt for Brine Tanks: High-purity sodium chloride, free of dirt and foreign material. Rock and granulated forms are not acceptable.
- H. HVAC Makeup Water Softener
1. Description: Twin mineral tanks and one brine tank, factory mounted on skid.
  2. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.
  3. Mineral Tanks:
    - a. Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - b. Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
    - c. Pressure Rating: 100 psig (690 kPa) OR 125 psig (860 kPa) OR 150 psig (1035 kPa), as directed, minimum.
    - d. Wetted Components: Suitable for water temperatures from 40 to at least 100 deg F (5 to at least 38 deg C).
    - e. Freeboard: 50 percent, minimum, for backwash expansion above the normal resin bed level.
    - f. Support Legs or Skirt: Constructed of structural steel, welded or bonded to tank before testing and labeling.
    - g. Finish: Hot-dip galvanized on exterior and interior of tank after fabrication.
    - h. Upper Distribution System: Single-point type, fabricated from galvanized-steel pipe and fittings.
    - i. Lower Distribution System: Hub and radial-arm or header-lateral type; fabricated from PVC pipe and fittings with individual, fine-slotted, nonclogging PE strainers; arranged for even-flow distribution through resin bed.
  4. Controls: Automatic; factory mounted on mineral tanks and factory wired.
    - a. Adjustable duration of regeneration steps.
    - b. Push-button start and complete manual operation override.
    - c. Pointer on pilot-control valve shall indicate cycle of operation.
    - d. Means of manual operation of pilot-control valve if power fails.
    - e. Main Operating Valves: Industrial, automatic, multiport, diaphragm type with the following features:

- 1) Slow opening and closing, nonslam operation.
- 2) Diaphragm guiding on full perimeter from fully open to fully closed.
- 3) Isolated dissimilar metals within valve.
- 4) Self-adjusting, internal, automatic brine injector that draws brine and rinses at constant rate independent of pressure.
- 5) Float-operated brine valve to automatically measure the correct amount of brine to the softener and refill with fresh water.
- 6) Sampling cocks for soft water.
- f. Flow Control: Automatic control of backwash and flush rates over variations in operating pressures that do not require field adjustments. Equip mineral tanks with automatic-reset-head water meter that electrically activates cycle controller to initiate regeneration at preset total in **gallons (liters)**, and automatically resets after regeneration to preset total in **gallons (liters)** for next service run. Include alternator to regenerate one mineral tank with the other in service.
5. Brine Tank: Combination measuring and wet-salt storing system.
  - a. Tank and Cover Material: Fiberglass a minimum of **3/16 inch (4.8 mm)** thick; or molded PE a minimum of **3/8 inch (9.5 mm)** thick.
  - b. Brine Valve: Float operated and plastic fitted for automatic control of brine withdrawn and freshwater refill.
  - c. Size: Large enough for at least four regenerations at full salting.
6. Factory-Installed Accessories:
  - a. Piping, valves, tubing, and drains.
  - b. Sampling cocks.
  - c. Main-operating-valve position indicators.
  - d. Water meters.
7. Water Test Kit: Include water test kit in wall-mounting enclosure for water softener.
- I. RO Equipment For HVAC Makeup Water
  1. Description: Factory fabricated and tested with RO membrane elements in housings, high-pressure pumps and motors, controls, valves, and prefilter; mounted on skid.
  2. Fabricate supports and attachments to tanks with reinforcement strong enough to resist tank movement during seismic event when tank supports are anchored to building structure as recommended in writing by manufacturer.
  3. Skid Assembly: Welded-steel frame coated with epoxy protective finish.
  4. RO Membrane and Housing:
    - a. Element: Thin-film composite with U-cup brine seal with minimum 98 percent salt rejection based on 2000-ppm water supplied at **225 psig (1551 kPa)** and **77 deg F (25 deg C)**.
    - b. Housing: ASTM A 666, Type 304 stainless steel with PVC end caps held in place with stainless-steel straps.
  5. High-Pressure Pumps and Motors:
    - a. Pump:
      - 1) Vertical, multistage centrifugal operating at 3500 rpm with ASTM A 666, Type 304 stainless-steel casing, shaft, impellers, and inlet and discharge casting.
      - 2) Bearings shall be tungsten carbide and ceramic.
      - 3) Cast-iron frame and flanged suction and discharge connections.
    - b. Motor: NEMA-standard, C-faced TEFC motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  6. Controls:
    - a. Microprocessor-based controller with LCD display.
    - b. Interlock for remote start/stop control.
    - c. Membrane flush sequence when pumps shut down.
    - d. Run time indicator.
    - e. Low-pressure safety cutoff.
    - f. Panel-mounted gages as follows:

- 1) Product and concentrate.
  - 2) Inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product pressures.
  - 3) Product conductivity monitor.
7. Valves:
    - a. Stainless-steel pump, concentrate, and recycle throttling valves rated for minimum **300 psig (2068 kPa)**.
    - b. Automatic inlet shutoff valve, diaphragm type; solenoid actuated, normally closed, and constructed of glass-reinforced noryl thermoplastic.
    - c. PVC valves with EPDM seats and seals for isolation at inlet, and check and sample valves at product and concentrate. Sample valves at cartridge filter outlet, concentrate, and product outlet.
  8. Prefilter:
    - a. Housing: Polypropylene with built-in relief or vent valve.
    - b. Element: Spun-wound polypropylene.
  9. Inlet Water Tempering Valve: Thermostatic water-tempering valve to maintain **77 deg F (25 deg C)**, **as directed**, inlet water temperature to RO unit.
  10. Activated Carbon Filter:
    - a. Media Tank: Fiberglass-reinforced polyester rated for minimum **150 psig (1035 kPa)** with internal backwash distributor and filtered water collector.
    - b. Media: 12 x 40-mesh, bituminous coal-based activated carbon.
    - c. Backwash Valve: Piston-operated control valve with drain-line, flow-control orifice.
    - d. Backwash Control: Seven-day time clock.
  11. Atmospheric Storage Tank:
    - a. Tank: Polyethylene single piece with closed top and flat bottom with manway in top, 0.2-micron filter vent, inlet, discharge, and drain piping connections, and bulkhead fittings for level controls.
    - b. Control: Level switches start and stop RO unit. Low-level limit shall stop repressurization pumps, and signal an alarm.
  12. Repressurization Pumps:
    - a. Pumps: Two close-coupled, single-stage centrifugal pumps, with mechanical seals. Wetted components ASTM A 666, Type 316 stainless steel.
    - b. Controls: NEMA-4X pump control panel constructed of fiberglass to control pumps, one operating, one standby, with automatic alternator and fail-over control.
    - c. Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  13. Water Test Kit: Include water test kit in wall-mounting cabinet for RO unit.
- J. Filtration Equipment
1. Multimedia Filters:
    - a. Description: Factory-fabricated and -tested, simplex, multimedia filter system of filter tank, media, strainer, circulating pump, piping, and controls for removing particles from water.
      - 1) Filter Tank: Corrosion resistant with distribution system and media.
        - a) Fabricate and label steel filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
        - b) Fabricate and label FRP filter tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, if indicated.
        - c) Pipe Connections **NPS 2 (DN 50)** and Smaller: Threaded according to ASME B1.20.1.
        - d) Steel Tank Pipe Connections **NPS 2-1/2 (DN 65)** and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
        - e) FRP Tank Pipe Connections **NPS 2-1/2 (DN 65)** and Larger: Type A, integral; Designation **E, 125-psig (0.862-MPa)** or **F, 150-psig (1.034-MPa)** pressure category flanges of grade same as tank material according to ASTM D 5421.



- 2) Motorized Valves: Flanged or grooved-end, ductile-iron butterfly type with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
  - 3) Strainer: Basket type mounted on pump suction.
  - 4) Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
  - 5) Piping: **ASTM B 88, Type L (ASTM B 88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
  - 6) Safety Valves: Automatic pressure relief.
  - 7) Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
    - a) Casing: Radially split, cast iron.
    - b) Pressure Rating: **125 psig (860 kPa) OR 150 psig (1035 kPa), as directed**, minimum.
    - c) Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
    - d) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
    - e) Seal: Mechanical.
    - f) Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - 8) Controls: Automatic control of circulating pump and tank backwash; factory wired for single electrical connection.
    - a) Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.
    - b) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
    - c) Backwash: Automatic; with time clock and differential pressure switch.
    - d) Backwash Valve: Tank mounted with valves interlocked to single actuator.
  - 9) Support: Skid mounting. Fabricate supports and base and attachment to tank with reinforcement strong enough to resist filter movement during a seismic event when filter base is anchored to building structure.
2. Self-Cleaning Strainers:
- a. Description: Factory-fabricated and -tested, ASTM A 126, Class B, cast-iron or steel, self-cleaning strainer system of tank, strainer, backwash arm or cleaning spiral, drive and motor, piping, and controls for removing particles from water.
    - 1) Fabricate and label ASTM A 126, Class B, cast-iron or steel strainer tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - 2) Pipe Connections:
      - a) **NPS 2 (DN 50)** and Smaller: Threaded according to ASME B1.20.1.
      - b) **NPS 2-1/2 (DN 65)** and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
  - b. Motorized Valves: Flanged or grooved-end, ductile-iron angle type with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
  - c. Strainer: ASTM A 666, Type 316 stainless steel.
  - d. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
  - e. Safety Valves: Automatic pressure relief.
  - f. Backwash Arm Drive:
    - 1) Drive Casing: Cast iron.
    - 2) Worm Gears: Immersed in oil.
    - 3) Motor: ODP motor supported on the strainer-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - g. Controls: Automatic control of backwash; factory wired for single electrical connection.
    - 1) Panel: NEMA 250, Type 4 enclosure with time clock and pressure gages.

- 2) Backwash Arm Drive: Automatic and manual switching; manual switch position bypasses safeties and controls.
- 3) Backwash: Automatic; with time clock and differential pressure switch.
- 4) Backwash Valve: Electric actuator.
- h. Support: Skid mounting. Fabricate supports and base and attachment to tank with reinforcement strong enough to resist strainer movement during a seismic event when strainer base is anchored to building structure.
3. Bag **OR** Cartridge, **as directed**, -Type Filters:
  - a. Description: Floor-mounting housing with filter bags **OR** cartridges, **as directed**, for removing particles from water.
    - 1) Housing: Corrosion resistant; designed to separate inlet from outlet and to direct inlet through bag **OR** cartridge, **as directed**, -type water filter; with bag support and base, feet, or skirt.
      - a) Pipe Connections **NPS 2 (DN 50)** and Smaller: Threaded according to ASME B1.20.1.
      - b) Steel Housing Pipe Connections **NPS 2-1/2 (DN 65)** and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606.
      - c) Plastic Housing Pipe Connections **NPS 2-1/2 (DN 65)** and Larger: **150-psig (1035-kPa)** plastic flanges.
    - 2) Bag **OR** Cartridge, **as directed**: Replaceable; of shape to fit housing.
4. Centrifugal Separators:
  - a. Description: Simplex separator housing with baffles and chambers for removing particles from water by centrifugal action and gravity.
  - b. Housing: With manufacturer's proprietary system of baffles and chambers.
    - 1) Construction: Fabricate and label steel separator housing to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - 2) Inlet: Designed with tangential entry to produce centrifugal flow of feedwater.
    - 3) Vortex Chamber: Designed for downward vortex flow and gravity separation of particles.
    - 4) Collection Chamber: Designed to hold separated particles.
    - 5) Outlet: Near top of unit.
    - 6) Purge: At bottom of collection chamber.
    - 7) Pipe Connections **NPS 2 (DN 50)** and Smaller: Threaded according to ASME B1.20.1.
    - 8) Pipe Connections **NPS 2-1/2 (DN 65)** and Larger: Steel, Class 150 flanges according to ASME B16.5 or grooved according to AWWA C606. Provide stainless-steel flanges if tank is stainless steel.
  - c. Motorized Purge Valve: Gate or plug pattern valve.
    - 1) Motorized Valves: Butterfly-type, flanged or grooved-end, ductile-iron body, with EPDM valve seat and stem seal; with ASTM B 148 aluminum bronze disc.
  - d. Strainer: Stainless-steel basket type mounted on pump suction.
  - e. Piping: ASTM A 53/A 53M, Type S, F, or E; Grade B, Schedule 40 black steel, with flanged, grooved, or threaded joints and malleable, steel welding, or ductile-iron fittings.
  - f. Piping: **ASTM B 88, Type L (ASTM B 88M, Type B)** copper water tube, copper-alloy solder-joint fittings, and brazed, flanged, or grooved joints.
  - g. Circulating Pump: Overhung impeller, close coupled, single stage, end suction, centrifugal. Comply with UL 778 and with HI 1.1-1.2 and HI 1.3.
    - 1) Casing: Radially split, cast iron.
    - 2) Pressure Rating: **125 psig (860 kPa) OR 150 psig (1035 kPa), as directed**, minimum.
    - 3) Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
    - 4) Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
    - 5) Seal: Mechanical.



- 6) Motor: ODP motor supported on the pump-bearing frame. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- h. Controls: Automatic control of circulating pump and separator purge; factory wired for single electrical connection.
  - 1) Panel: NEMA 250, Type 4 enclosure.
  - 2) Pump: Automatic and manual switching; manual switch position bypasses safeties and controls.
  - 3) Separator Purge: Automatic and manual.
  - 4) TDS Controller Interlock: Open separator purge valve with bleed-off control.
- i. Support: Skid mounting. Fabricate supports and base and attachment to separator housing with reinforcement strong enough to resist separator movement during a seismic event when separator base is anchored to building structure.

### 1.3 EXECUTION

#### A. Water Analysis

1. Perform an analysis of supply water to determine quality of water available at Project site.

#### B. Installation

1. Install chemical application equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor chemical tanks and floor-mounting accessories to substrate.
2. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
3. Install water testing equipment on wall near water chemical application equipment.
4. Install interconnecting control wiring for chemical treatment controls and sensors.
5. Mount sensors and injectors in piping circuits.
6. Bypass Feeders: Install in closed hydronic systems, including hot-water heating, chilled water, dual-temperature water, and glycol cooling, and equipped with the following:
  - a. Install bypass feeder in a bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
  - b. Install water meter in makeup water supply.
  - c. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
  - d. Install a gate or full-port ball isolation valves on inlet, outlet, and drain below feeder inlet.
  - e. Install a swing check on inlet after the isolation valve.
7. Install automatic chemical-feed equipment for steam boiler and steam condensate systems and include the following:
  - a. Install makeup water softener.
  - b. Install water meter in makeup water supply.
  - c. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
    - 1) Pumps shall operate for timed interval when contacts close at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
  - d. Install test equipment and furnish test-kit to the Owner.
  - e. Install RO unit for makeup water.
  - f. Install TDS controller with sensor and bleed valves.
    - 1) Bleed valves shall cycle to maintain maximum TDS concentration.
  - g. Install inhibitor injection timer with injection pumps and solution tanks.

- 1) Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into main steam supply header.
8. Install automatic chemical-feed equipment for condenser **OR** fluid-cooler spray, **as directed**, water and include the following:
  - a. Install makeup water softener.
  - b. Install water meter in makeup water supply.
  - c. Install inhibitor injection pumps and solution tanks with injection timer sensing contacts in water meter.
    - 1) Pumps shall operate for timed interval on contact closure at water meter in makeup water supply connection. Injection pump shall discharge into boiler feedwater tank or feedwater supply connection at boiler.
  - d. Install test equipment and provide test-kit to the Owner. Install test-coupon assembly in bypass circuit around circulating pumps, unless otherwise indicated on Drawings.
  - e. Install TDS controller with sensor and bleed valves.
    - 1) Bleed valves shall cycle to maintain maximum TDS concentration.
  - f. Install pH sensor and controller with injection pumps and solution tanks.
    - 1) Injector pumps shall operate to maintain required pH.
  - g. Install biocide feeder alternating timer with two sets of injection pumps and solution tanks.
    - 1) Injection pumps shall operate to feed biocide on an alternating basis.
  - h. Install ozone generator with diffusers in condenser-water piping.
  - i. Ozone generator shall operate continuously with condenser-water flow.
  - j. Install UV-irradiation lamps in condenser-water piping.
    - 1) UV lights shall operate continuously with condenser-water flow.
- C. Ozone-Generator Installation
  1. Install ozone generator and equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
  2. Install seismic restraints for equipment and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
  3. Pipe ozone from ozone generator to condenser water with stainless-steel pipe and fittings with welded joints.
  4. Install two **OR** three, **as directed**,-piece, stainless-steel ball valve in ozone supply to condenser water.
  5. Pipe cooling water to ozone generator, and to air-gap drain fitting with stainless-steel pipe and fittings with welded joints where enclosed in ozone-generator room.
  6. Install two **OR** three, **as directed**,-piece, stainless-steel ball valve in cooling water supply to ozone generator.
  7. Mounting supports for ozone generator shall be ASTM A 666, Type 316 stainless steel.
  8. Mount breathing apparatus outside ozone-generator room.
  9. Mount and install ozone detector, warning lights, and audible alarm inside ozone-generator room. Mount another set of warning lights and audible alarm just outside the main entrance to ozone-generator room.
- D. UV-Irradiation Unit Installation
  1. Install UV-irradiation units on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
  2. Install seismic restraints for UV-irradiation units and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
- E. Water Softener Installation

1. Install water softener equipment on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor mineral and brine tanks and floor-mounting accessories to substrate.
2. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
3. Install brine lines and fittings furnished by equipment manufacturer but not factory installed.
4. Prepare mineral-tank distribution system and underbed for minerals and place specified mineral into mineral tanks.
5. Install water-testing sets on wall adjacent to water softeners.

F. RO Unit Installation

1. Install RO unit and storage tank on concrete bases, level and plumb. Maintain manufacturer's recommended clearances. Arrange units so controls and devices that require servicing are accessible. Anchor RO unit and storage tank with pumps to substrate.
2. Install seismic restraints for tanks and floor-mounting accessories and anchor to building structure. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for seismic restraints.
3. Install interconnecting piping and controls furnished by equipment manufacturer but not factory installed.
4. Install water testing sets on wall adjacent to RO unit.

G. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to equipment to allow service and maintenance.
3. Make piping connections between HVAC water-treatment equipment and dissimilar-metal piping with dielectric fittings. Dielectric fittings are specified in Division 23 Section "Common Work Results For Hvac".
4. Install shutoff valves on HVAC water-treatment equipment inlet and outlet. Metal general-duty valves are specified in Division 23 Section "General-duty Valves For Hvac Piping".
5. Refer to Division 22 Section "Domestic Water Piping Specialties" for backflow preventers required in makeup water connections to potable-water systems.
6. Confirm applicable electrical requirements in Division 22 for connecting electrical equipment.
7. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
8. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

H. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. Perform tests and inspections and prepare test reports.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
  - a. Inspect field-assembled components and equipment installation, including piping and electrical connections.
  - b. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
  - c. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.

- d. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
- e. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
- f. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
- g. Cap and subject piping to static water pressure of **50 psig (345 kPa)** above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
- h. Repair leaks and defects with new materials and retest piping until no leaks exist.
4. Remove and replace malfunctioning units and retest as specified above.
5. Sample boiler water at one-week intervals after boiler startup for a period of five weeks, and prepare test report advising the Owner of changes necessary to adhere to Part 1 "Performance Requirements" Article for each required characteristic. Sample boiler water at four **OR** six **OR** eight, **as directed**, -week intervals following the testing noted above to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section.
6. At four **OR** six **OR** eight, **as directed**, -week intervals following Final Completion, perform separate water analyses on hydronic systems to show that automatic chemical-feed systems are maintaining water quality within performance requirements specified in this Section. Submit written reports of water analysis advising the Owner of changes necessary to adhere to Part 1.1 "Performance Requirements" Article.
7. Comply with ASTM D 3370 and with the following standards:
  - a. Silica: ASTM D 859.
  - b. Steam System: ASTM D 1066.
  - c. Acidity and Alkalinity: ASTM D 1067.
  - d. Iron: ASTM D 1068.
  - e. Water Hardness: ASTM D 1126.
- I. Demonstration
  1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain HVAC water-treatment systems and equipment.

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Task	Specification	Specification Description
23 25 13 00	21 05 23 00	Piped Utilities Basic Materials And Methods
23 25 13 00	22 12 23 26	Underground Storage Tanks
23 25 13 00	22 11 16 00c	Hydronic Piping

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## SECTION 23 31 13 13 - METAL DUCTS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for metal ducts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Single-wall rectangular ducts and fittings.
  - b. Double-wall rectangular ducts and fittings.
  - c. Single-wall round and flat-oval ducts and fittings.
  - d. Double-wall round and flat-oval ducts and fittings.
  - e. Sheet metal materials.
  - f. Duct liner.
  - g. Sealants and gaskets.
  - h. Hangers and supports.
  - i. Seismic-restraint devices.

#### C. Performance Requirements

1. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.
2. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
  - a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.  
**OR**  
Seismic Hazard Level B: Seismic force to weight ratio, 0.30.  
**OR**  
Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

#### D. Submittals

1. Product Data: For each type of the following products:
  - a. Liners and adhesives.
  - b. Sealants and gaskets.
  - c. Seismic-restraint devices.
2. LEED Submittals:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
  - b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
  - c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
  - d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-Up."

- e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:
  - a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
  - b. Factory- and shop-fabricated ducts and fittings.
  - c. Duct layout indicating sizes, configuration, liner material, and static-pressure classes.
  - d. Elevation of top of ducts.
  - e. Dimensions of main duct runs from building grid lines.
  - f. Fittings.
  - g. Reinforcement and spacing.
  - h. Seam and joint construction.
  - i. Penetrations through fire-rated and other partitions.
  - j. Equipment installation based on equipment being used on Project.
  - k. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
  - l. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
4. Delegated-Design Submittal:
  - a. Sheet metal thicknesses.
  - b. Joint and seam construction and sealing.
  - c. Reinforcement details and spacing.
  - d. Materials, fabrication, assembly, and spacing of hangers and supports.
  - e. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation for selecting hangers and supports and seismic restraints.
5. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
  - b. Suspended ceiling components.
  - c. Structural members to which duct will be attached.
  - d. Size and location of initial access modules for acoustical tile.
  - e. Penetrations of smoke barriers and fire-rated construction.
  - f. Items penetrating finished ceiling including the following:
    - 1) Lighting fixtures.
    - 2) Air outlets and inlets.
    - 3) Speakers.
    - 4) Sprinklers.
    - 5) Access panels.
    - 6) Perimeter moldings.
6. Welding certificates.
7. Field quality-control reports.

E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
  - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
  - b. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
  - c. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

## 1.2 PRODUCTS

- A. Single-Wall Rectangular Ducts And Fittings
1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
  2. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  3. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  4. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Double-Wall Rectangular Ducts And Fittings
1. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.
  2. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.
  3. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  4. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  5. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
    - a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
    - b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
    - c. Coat insulation with antimicrobial coating.
    - d. Cover insulation with polyester film complying with UL 181, Class 1.

**OR**
  6. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
    - a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
  7. Inner Duct: Minimum 0.028-inch (0.7-mm) perforated galvanized sheet steel having 3/32-inch (2.4-mm-) diameter perforations, with overall open area of 23 percent **OR** solid sheet steel, **as directed**.
  8. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

9. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

C. Single-Wall Round And Flat-Oval Ducts And Fittings

1. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.
2. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).
3. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - a. Transverse Joints in Ducts Larger Than **60 Inches (1524 mm)** in Diameter: Flanged.
4. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
  - a. Fabricate round ducts larger than **90 inches (2286 mm)** in diameter with butt-welded longitudinal seams.
  - b. Fabricate flat-oval ducts larger than **72 inches (1830 mm)** in width (major dimension) with butt-welded longitudinal seams.
5. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Double-Wall Round And Flat-Oval Ducts And Fittings

1. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.
2. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.
  - a. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
    - 1) Transverse Joints in Ducts Larger Than **60 Inches (1524 mm)** in Diameter: Flanged.
  - b. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
    - 1) Fabricate round ducts larger than **90 inches (2286 mm)** in diameter with butt-welded longitudinal seams.
    - 2) Fabricate flat-oval ducts larger than **72 inches (1830 mm)** in width (major dimension) with butt-welded longitudinal seams.
  - c. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static-pressure class, applicable sealing requirements,

- materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
3. Inner Duct: Minimum **0.028-inch (0.7-mm)** perforated galvanized sheet steel having **3/32-inch-(2.4-mm-)** diameter perforations, with overall open area of 23 percent **OR** solid sheet steel, **as directed**.
  4. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
    - a. Maximum Thermal Conductivity: **0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)** at **75 deg F (24 deg C)** mean temperature.
    - b. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
    - c. Coat insulation with antimicrobial coating.
    - d. Cover insulation with polyester film complying with UL 181, Class 1.
  - OR**
  5. Interstitial Insulation: Flexible elastomeric duct liner complying with ASTM C 534, Type II for sheet materials, and with NFPA 90A or NFPA 90B.
    - a. Maximum Thermal Conductivity: **0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)** at **75 deg F (24 deg C)** mean temperature.
- E. Sheet Metal Materials
1. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
  2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
    - a. Galvanized Coating Designation: **G60 (Z180) OR G90 (Z275), as directed**.
    - b. Finishes for Surfaces Exposed to View: Mill phosphatized.
  3. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
    - a. Galvanized Coating Designation: **G60 (Z180) OR G90 (Z275), as directed**.
    - b. Minimum Thickness for Factory-Applied PVC Coating: **4 mils (0.10 mm)** thick on sheet metal surface of ducts and fittings exposed to corrosive conditions, and minimum **1 mil (0.025 mm)** thick on opposite surface, **as directed**.
    - c. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.
  4. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
  5. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" Article.
  6. Aluminum Sheets: Comply with **ASTM B 209 (ASTM B 209M)** Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
  7. Factory- or Shop-Applied Antimicrobial Coating:
    - a. Apply to the surface of sheet metal that will form the interior surface of the duct. An untreated clear coating shall be applied to the exterior surface.
    - b. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
    - c. Coating containing the antimicrobial compound shall have a hardness of 2H, minimum, when tested according to ASTM D 3363.
    - d. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
    - e. Shop-Applied Coating Color: Black **OR** White, **as directed**.
    - f. Antimicrobial coating on sheet metal is not required for duct containing liner treated with antimicrobial coating.
  8. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.





- a. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
9. Tie Rods: Galvanized steel, **1/4-inch (6-mm)** minimum diameter for lengths **36 inches (900 mm)** or less; **3/8-inch (10-mm)** minimum diameter for lengths longer than **36 inches (900 mm)**.

F. Duct Liner

1. Fibrous-Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
  - a. Maximum Thermal Conductivity:
    - 1) Type I, Flexible: **0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)** at **75 deg F (24 deg C)** mean temperature.
    - 2) Type II, Rigid: **0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K)** at **75 deg F (24 deg C)** mean temperature.
  - b. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
  - c. Solvent-Based **OR** Water-Based, **as directed**, Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
    - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
  - a. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
  - b. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
    - 1) For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Natural-Fiber Duct Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor and complying with NFPA 90A or NFPA 90B.
  - a. Maximum Thermal Conductivity: **0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)** at **75 deg F (24 deg C)** mean temperature when tested according to ASTM C 518.
  - b. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to ASTM E 84; certified by an NRTL.
  - c. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
    - 1) For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Insulation Pins and Washers:
  - a. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, **0.106-inch- (2.6-mm-) OR 0.135-inch- (3.5-mm-)**, **as directed**, diameter shank, length to suit depth of insulation indicated with integral **1-1/2-inch (38-mm)** galvanized carbon-steel washer.
  - b. Insulation-Retaining Washers: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick galvanized steel **OR** aluminum **OR** stainless steel, **as directed**; with beveled edge sized as required to hold insulation securely in place but not less than **1-1/2 inches (38 mm)** in diameter.
5. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
  - a. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
  - b. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.

- c. Butt transverse joints without gaps, and coat joint with adhesive.
  - d. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
  - e. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
  - f. Apply adhesive coating on longitudinal seams in ducts with air velocity of **2500 fpm (12.7 m/s)**.
  - g. Secure liner with mechanical fasteners **4 inches (100 mm)** from corners and at intervals not exceeding **12 inches (300 mm)** transversely; at **3 inches (75 mm)** from transverse joints and at intervals not exceeding **18 inches (450 mm)** longitudinally.
  - h. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
    - 1) Fan discharges.
    - 2) Intervals of lined duct preceding unlined duct.
    - 3) Upstream edges of transverse joints in ducts where air velocities are higher than **2500 fpm (12.7 m/s)** or where indicated.
  - i. Secure insulation between perforated sheet metal inner duct of same thickness as specified for outer shell. Use mechanical fasteners that maintain inner duct at uniform distance from outer shell without compressing insulation.
    - 1) Sheet Metal Inner Duct Perforations: **3/32-inch (2.4-mm)** diameter, with an overall open area of 23 percent.
  - j. Terminate inner ducts with buildouts attached to fire-damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.
- G. Sealant And Gaskets
- 1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
  - 2. Two-Part Tape Sealing System:
    - a. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
    - b. Tape Width: **3 inches (76 mm) OR 4 inches (102 mm) OR 6 inches (152 mm), as directed.**
    - c. Sealant: Modified styrene acrylic.
    - d. Water resistant.
    - e. Mold and mildew resistant.
    - f. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive and negative.
    - g. Service: Indoor and outdoor.
    - h. Service Temperature: **Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C)**.
    - i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
    - j. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 3. Water-Based Joint and Seam Sealant:
    - a. Application Method: Brush on.
    - b. Solids Content: Minimum 65 percent.
    - c. Shore A Hardness: Minimum 20.
    - d. Water resistant.
    - e. Mold and mildew resistant.
    - f. VOC: Maximum 75 g/L (less water).
    - g. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive and negative.
    - h. Service: Indoor or outdoor.



- i. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
  - 4. Solvent-Based Joint and Seam Sealant:
    - a. Application Method: Brush on.
    - b. Base: Synthetic rubber resin.
    - c. Solvent: Toluene and heptane.
    - d. Solids Content: Minimum 60 percent.
    - e. Shore A Hardness: Minimum 60.
    - f. Water resistant.
    - g. Mold and mildew resistant.
    - h. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - i. VOC: Maximum 395 g/L.
    - j. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive or negative.
    - k. Service: Indoor or outdoor.
    - l. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.
  - 5. Flanged Joint Sealant: Comply with ASTM C 920.
    - a. General: Single-component, acid-curing, silicone, elastomeric.
    - b. Type: S.
    - c. Grade: NS.
    - d. Class: 25.
    - e. Use: O.
    - f. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - 6. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
  - 7. Round Duct Joint O-Ring Seals:
    - a. Seal shall provide maximum leakage class of **3 cfm/100 sq. ft. at 1-inch wg (0.14 L/s per sq. m at 250 Pa)** and shall be rated for **10-inch wg (2500-Pa)** static-pressure class, positive or negative.
    - b. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
    - c. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.
- H. Hangers And Supports
  - 1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
  - 2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
  - 3. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," **Table 4-1 (Table 4-1M)**, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
  - 4. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
  - 5. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.
  - 6. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
  - 7. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
  - 8. Trapeze and Riser Supports:
    - a. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
    - b. Supports for Stainless-Steel Ducts: Stainless-steel shapes and plates.
    - c. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.
- I. Seismic-Restraint Devices
  - 1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR**

the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.

- a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
3. Restraint Cables: ASTM A 603, galvanized-steel **OR** ASTM A 492, stainless-steel, **as directed**, cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

### 1.3 EXECUTION

#### A. Duct Installation

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air-handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
2. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
3. Install round and flat-oval ducts in maximum practical lengths.
4. Install ducts with fewest possible joints.
5. Install factory- or shop-fabricated fittings for changes in direction, size, and shape and for branch connections.
6. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
7. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
8. Install ducts with a clearance of 1 inch (25 mm), plus allowance for insulation thickness.
9. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
10. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches (38 mm).
11. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
12. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines", **as directed**.

#### B. Installation Of Exposed Ductwork

1. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
2. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.

3. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
  4. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
  5. Repair or replace damaged sections and finished work that does not comply with these requirements.
- C. Additional Installation Requirements For Commercial Kitchen Hood Exhaust Duct
1. Install commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.
  2. Install fire-rated access panel assemblies at each change in direction and at maximum intervals of **20 feet (6 m) OR 12 feet (3.7 m)**, as directed, in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of **1-1/2 inches (38 mm)** from bottom of duct.
  3. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.
- D. Duct Sealing
1. Seal ducts for duct static-pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."  
**OR**  
Seal ducts to the following seal classes according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible":
    - a. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
    - b. Outdoor, Supply-Air Ducts: Seal Class A.
    - c. Outdoor, Exhaust Ducts: Seal Class C.
    - d. Outdoor, Return-Air Ducts: Seal Class C.
    - e. Unconditioned Space, Supply-Air Ducts in Pressure Classes **2-Inch wg (500 Pa)** and Lower: Seal Class B.
    - f. Unconditioned Space, Supply-Air Ducts in Pressure Classes Higher Than **2-Inch wg (500 Pa)**: Seal Class A.
    - g. Unconditioned Space, Exhaust Ducts: Seal Class C.
    - h. Unconditioned Space, Return-Air Ducts: Seal Class B.
    - i. Conditioned Space, Supply-Air Ducts in Pressure Classes **2-Inch wg (500 Pa)** and Lower: Seal Class C.
    - j. Conditioned Space, Supply-Air Ducts in Pressure Classes Higher Than **2-Inch wg (500 Pa)**: Seal Class B.
    - k. Conditioned Space, Exhaust Ducts: Seal Class B.
    - l. Conditioned Space, Return-Air Ducts: Seal Class C.
- E. Hanger And Support Installation
1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
  2. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
    - a. Where practical, install concrete inserts before placing concrete.
    - b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
    - c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than **4 inches (100 mm)** thick.
    - d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than **4 inches (100 mm)** thick.
    - e. Do not use powder-actuated concrete fasteners for seismic restraints.

3. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," **Table 4-1 (Table 4-1M)**, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within **24 inches (610 mm)** of each elbow and within **48 inches (1200 mm)** of each branch intersection.
  4. Hangers Exposed to View: Threaded rod and angle or channel supports.
  5. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of **16 feet (5 m)**.
  6. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- F. Seismic-Restraint-Device Installation
1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR ASCE/SEI 7, as directed**.
    - a. Space lateral supports a maximum of **40 feet (12 m)** o.c., and longitudinal supports a maximum of **80 feet (24 m)** o.c.
    - b. Brace a change of direction longer than **12 feet (3.7 m)**.
  2. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
  3. Install cables so they do not bend across edges of adjacent equipment or building structure.
  4. Install cable restraints on ducts that are suspended with vibration isolators.
  5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
  6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.
  7. Drilling for and Setting Anchors:
    - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
    - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
    - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
    - d. Set anchors to manufacturer's recommended torque, using a torque wrench.
    - e. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.
- G. Connections
1. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories".
  2. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.
- H. Painting
1. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 07.
- I. Field Quality Control
1. Perform tests and inspections.



2. Leakage Tests:
  - a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
  - b. Test the following systems:
    - 1) Ducts with a Pressure Class Higher Than **3-Inch wg (750 Pa)**: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 25 percent of total installed duct area for each designated pressure class.
    - 2) Supply Ducts with a Pressure Class of **2-Inch wg (500 Pa) OR 3-Inch wg (750 Pa) OR 4-Inch wg (1000 Pa)**, **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
    - 3) Return Ducts with a Pressure Class of **2-Inch wg (500 Pa) OR 3-Inch wg (750 Pa) OR 4-Inch wg (1000 Pa)**, **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
    - 4) Exhaust Ducts with a Pressure Class of **2-Inch wg (500 Pa) OR 3-Inch wg (750 Pa) OR 4-Inch wg (1000 Pa)**, **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
    - 5) Outdoor Air Ducts with a Pressure Class of **2-Inch wg (500 Pa) OR 3-Inch wg (750 Pa) OR 4-Inch wg (1000 Pa)**, **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
  - c. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  - d. Test for leaks before applying external insulation.
  - e. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
  - f. Give seven days' advance notice for testing.
3. Duct System Cleanliness Tests:
  - a. Visually inspect duct system to ensure that no visible contaminants are present.
  - b. Test sections of metal duct system, chosen randomly by the Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
    - 1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
4. Duct system will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

#### J. Duct Cleaning

1. Clean new **OR** existing **OR** new and existing, **as directed**, duct system(s) before testing, adjusting, and balancing.
2. Use service openings for entry and inspection.
  - a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch insulation and liner as recommended by duct liner manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
  - b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
  - c. Remove and reinstall ceiling to gain access during the cleaning process.



3. Particulate Collection and Odor Control:
    - a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
    - b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
  4. Clean the following components by removing surface contaminants and deposits:
    - a. Air outlets and inlets (registers, grilles, and diffusers).
    - b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
    - c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
    - d. Coils and related components.
    - e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
    - f. Supply-air ducts, dampers, actuators, and turning vanes.
    - g. Dedicated exhaust and ventilation components and makeup air systems.
  5. Mechanical Cleaning Methodology:
    - a. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
    - b. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
    - c. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts, duct liner, or duct accessories.
    - d. Clean fibrous-glass duct liner with HEPA vacuuming equipment; do not permit duct liner to get wet. Replace fibrous-glass duct liner that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
    - e. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
    - f. Provide drainage and cleanup for wash-down procedures.
    - g. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.
- K. Start Up
1. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, And Balancing For Hvac".
- L. Duct Schedule
1. Fabricate ducts with galvanized sheet steel except as otherwise indicated and as follows:
    - a. Underground Ducts: Concrete-encased, galvanized sheet steel **OR** PVC-coated, galvanized sheet steel with thicker coating on duct exterior **OR** stainless steel, **as directed**.
  2. Supply Ducts:
    - a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
      - 1) Pressure Class: Positive **1-inch wg (250 Pa) OR 2-inch wg (500 Pa), as directed**.
      - 2) Minimum SMACNA Seal Class: **A OR B OR C, as directed**.
      - 3) SMACNA Leakage Class for Rectangular: **12 OR 24, as directed**.
      - 4) SMACNA Leakage Class for Round and Flat Oval: **12 OR 24, as directed**.
    - b. Ducts Connected to Constant-Volume Air-Handling Units:
      - 1) Pressure Class: Positive **2-inch wg (500 Pa) OR 3-inch wg (750 Pa), as directed**.
      - 2) Minimum SMACNA Seal Class: **A OR B, as directed**.
      - 3) SMACNA Leakage Class for Rectangular: **6 OR 12 OR 24, as directed**.

- 4) SMACNA Leakage Class for Round and Flat Oval: 6 OR 12 OR 24, as directed.
- c. Ducts Connected to Variable-Air-Volume Air-Handling Units:
  - 1) Pressure Class: Positive 3-inch wg (750 Pa) OR 4-inch wg (1000 Pa), as directed.
  - 2) Minimum SMACNA Seal Class: A OR B, as directed.
  - 3) SMACNA Leakage Class for Rectangular: 3 OR 6, as directed.
  - 4) SMACNA Leakage Class for Round and Flat Oval: 3 OR 6, as directed.
- d. Ducts Connected to Equipment Not Listed Above:
  - 1) Pressure Class: Positive 2-inch wg (500 Pa) OR 3-inch wg (750 Pa) OR 4-inch wg (1000 Pa), as directed.
  - 2) Minimum SMACNA Seal Class: A OR B, as directed.
  - 3) SMACNA Leakage Class for Rectangular: 3 OR 6 OR 12, as directed.
  - 4) SMACNA Leakage Class for Round and Flat Oval: 3 OR 6 OR 12, as directed.
3. Return Ducts:
  - a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - 1) Pressure Class: Positive or negative 1-inch wg (250 Pa) OR 2-inch wg (500 Pa), as directed.
    - 2) Minimum SMACNA Seal Class: A OR B OR C, as directed.
    - 3) SMACNA Leakage Class for Rectangular: 12 OR 24, as directed.
    - 4) SMACNA Leakage Class for Round and Flat Oval: 12 OR 24, as directed.
  - b. Ducts Connected to Air-Handling Units:
    - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) OR 3-inch wg (750 Pa), as directed.
    - 2) Minimum SMACNA Seal Class: A OR B, as directed.
    - 3) SMACNA Leakage Class for Rectangular: 6 OR 12 OR 24, as directed.
    - 4) SMACNA Leakage Class for Round and Flat Oval: 6 OR 12 OR 24, as directed.
  - c. Ducts Connected to Equipment Not Listed Above:
    - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) OR 3-inch wg (750 Pa) OR 4-inch wg (1000 Pa), as directed.
    - 2) Minimum SMACNA Seal Class: A OR B, as directed.
    - 3) SMACNA Leakage Class for Rectangular: 3 OR 6 OR 12, as directed.
    - 4) SMACNA Leakage Class for Round and Flat Oval: 3 OR 6 OR 12, as directed.
4. Exhaust Ducts:
  - a. Ducts Connected to Fans Exhausting (ASHRAE 62.1, Class 1 and 2) Air:
    - 1) Pressure Class: Negative 1-inch wg (250 Pa) OR 2-inch wg (500 Pa) OR 3-inch wg (750 Pa), as directed.
    - 2) Minimum SMACNA Seal Class: A OR B OR C, as directed, if negative pressure, and A if positive pressure.
    - 3) SMACNA Leakage Class for Rectangular: 12 OR 24, as directed.
    - 4) SMACNA Leakage Class for Round and Flat Oval: 6 OR 12 OR 24, as directed.
  - b. Ducts Connected to Air-Handling Units:
    - 1) Pressure Class: Positive or negative 2-inch wg (500 Pa) OR 3-inch wg (750 Pa) as directed.
    - 2) Minimum SMACNA Seal Class: A OR B, as directed, if negative pressure, and A if positive pressure.
    - 3) SMACNA Leakage Class for Rectangular: 6 OR 12 OR 24, as directed.
    - 4) SMACNA Leakage Class for Round and Flat Oval: 3 OR 6 OR 12 OR 24, as directed.
  - c. Ducts Connected to Commercial Kitchen Hoods: Comply with NFPA 96.
    - 1) Exposed to View: Type 304, stainless-steel sheet, No. 4 OR No. 3, as directed, finish.
    - 2) Concealed: Type 304, stainless-steel sheet, No. 2D finish OR Carbon-steel sheet, as directed.
    - 3) Welded seams and joints.
    - 4) Pressure Class: Positive or negative 2-inch wg (500 Pa) OR 3-inch wg (750 Pa) OR 4-inch wg (1000 Pa), as directed.



- 5) Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
- 6) SMACNA Leakage Class: 3.
- d. Ducts Connected to Dishwasher Hoods:
  - 1) Type 304, stainless-steel sheet.
  - 2) Exposed to View: No. 4 **OR** No. 3, **as directed**, finish.
  - 3) Concealed: No. 2D finish.
  - 4) Welded seams and flanged joints with watertight EPDM gaskets.
  - 5) Pressure Class: Positive or negative **2-inch wg (500 Pa) OR 3-inch wg (750 Pa), as directed.**
  - 6) Minimum SMACNA Seal Class: Welded seams, joints, and penetrations.
  - 7) SMACNA Leakage Class: 3.
- e. Ducts Connected to Fans Exhausting Laboratory and Process (ASHRAE 62.1, Class 3 and 4) Air:
  - 1) Type 316 **OR** Type 304, **as directed**, stainless-steel sheet.
    - a) Exposed to View: No. 4 **OR** No. 3, **as directed**, finish.
    - b) Concealed: No. 2B **OR** No. 2D, **as directed**, finish.
  - OR**  
PVC-coated, galvanized sheet steel with thicker coating on duct interior.
  - 2) Pressure Class: Positive or negative **3-inch wg (750 Pa) OR 4-inch wg (1000 Pa) OR 6-inch wg (1500 Pa), as directed.**
  - 3) Minimum SMACNA Seal Class: A **OR** Welded seams, joints, and penetrations, **as directed.**
  - 4) SMACNA Leakage Class: 3.
- f. Ducts Connected to Equipment Not Listed Above:
  - 1) Pressure Class: Positive or negative **2-inch wg (500 Pa) OR 3-inch wg (750 Pa) OR 4-inch wg (1000 Pa), as directed.**
  - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed**, if negative pressure, and A if positive pressure.
  - 3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed.**
  - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12 **OR** 24, **as directed.**
5. Outdoor-Air (Not Filtered, Heated, or Cooled) Ducts:
  - a. Ducts Connected to Fan Coil Units, Furnaces, Heat Pumps, and Terminal Units:
    - 1) Pressure Class: Positive or negative **1-inch wg (250 Pa) OR 2-inch wg (500 Pa), as directed.**
    - 2) Minimum SMACNA Seal Class: A **OR** B **OR** C, **as directed.**
    - 3) SMACNA Leakage Class for Rectangular: 12 **OR** 24, **as directed.**
    - 4) SMACNA Leakage Class for Round and Flat Oval: 6 **OR** 12 **OR** 24, **as directed.**
  - b. Ducts Connected to Air-Handling Units:
    - 1) Pressure Class: Positive or negative **2-inch wg (500 Pa) OR 3-inch wg (750 Pa), as directed.**
    - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed.**
    - 3) SMACNA Leakage Class for Rectangular: 6 **OR** 12 **OR** 24, **as directed.**
    - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12 **OR** 24, **as directed.**
  - c. Ducts Connected to Equipment Not Listed Above:
    - 1) Pressure Class: Positive or negative **2-inch wg (500 Pa) OR 3-inch wg (750 Pa) OR 4-inch wg (1000 Pa), as directed.**
    - 2) Minimum SMACNA Seal Class: A **OR** B, **as directed.**
    - 3) SMACNA Leakage Class for Rectangular: 3 **OR** 6 **OR** 12, **as directed.**
    - 4) SMACNA Leakage Class for Round and Flat Oval: 3 **OR** 6 **OR** 12, **as directed.**
6. Intermediate Reinforcement:
  - a. Galvanized-Steel Ducts: Galvanized steel **OR** Carbon steel coated with zinc-chromate primer **OR** Galvanized steel or carbon steel coated with zinc-chromate primer, **as directed.**
  - b. PVC-Coated Ducts:
    - 1) Exposed to Airstream: Match duct material.

- 2) Not Exposed to Airstream: Galvanized **OR** Match duct material, **as directed**.
  - c. Stainless-Steel Ducts:
    - 1) Exposed to Airstream: Match duct material.
    - 2) Not Exposed to Airstream: Galvanized **OR** Match duct material, **as directed**.
  - d. Aluminum Ducts: Aluminum **OR** galvanized sheet steel coated with zinc chromate, **as directed**.
7. Liner:
- a. Supply Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
  - b. Return Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
  - c. Exhaust Air Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) thick.
  - d. Supply Fan Plenums: Fibrous glass, Type II **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
  - e. Return- and Exhaust-Fan Plenums: Fibrous glass, Type II **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 2 inches (51 mm) thick.
  - f. Transfer Ducts: Fibrous glass, Type I **OR** Flexible elastomeric **OR** Natural fiber, **as directed**, 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
8. Double-Wall Duct Interstitial Insulation:
- a. Supply Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
  - b. Return Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
  - c. Exhaust Air Ducts: 1 inch (25 mm) **OR** 1-1/2 inches (38 mm) **OR** 2 inches (51 mm), **as directed**, thick.
9. Elbow Configuration:
- a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
    - 1) Velocity 1000 fpm (5 m/s) or Lower:
      - a) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
      - b) Mitered Type RE 4 without vanes.
    - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s):
      - a) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
      - b) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
      - c) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
    - 3) Velocity 1500 fpm (7.6 m/s) or Higher:
      - a) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
      - b) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
      - c) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
  - OR**
  - b. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
    - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
    - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.

- 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
- c. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
  - 1) Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
    - a) Velocity 1000 fpm (5 m/s) or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
    - b) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
    - c) Velocity 1500 fpm (7.6 m/s) or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
    - d) Radius-to Diameter Ratio: 1.5.
  - 2) Round Elbows, 12 Inches (305 mm) and Smaller in Diameter: Stamped or pleated.
  - 3) Round Elbows, 14 Inches (356 mm) and Larger in Diameter: Standing seam **OR** Welded, **as directed**.
10. Branch Configuration:
  - a. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
    - 1) Rectangular Main to Rectangular Branch: 45-degree entry.
    - 2) Rectangular Main to Round Branch: Spin in.
  - b. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
    - 1) Velocity 1000 fpm (5 m/s) or Lower: 90-degree tap.
    - 2) Velocity 1000 to 1500 fpm (5 to 7.6 m/s): Conical tap.
    - 3) Velocity 1500 fpm (7.6 m/s) or Higher: 45-degree lateral.

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## SECTION 23 31 13 13a - HVAC CASINGS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for HVAC casings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Factory- and Shop-fabricated, field-assembled, single- and double-wall casings for HVAC equipment.

#### C. Performance Requirements

1. Static-Pressure Classes:
  - a. Upstream from Fan(s): **2-inch wg (500 Pa).**
  - b. Downstream from Fan(s): **2-inch wg (500 Pa) OR 3-inch wg (750 Pa) OR 4-inch wg (1000 Pa) OR 6-inch wg (1500 Pa) OR 10-inch wg (2500 Pa), as directed.**
2. Acoustical Performance:
  - a. NRC: **1.09 OR 0.94, as directed**, according to ASTM C 423.
  - b. STC: **40 OR 34, as directed**, according to ASTM E 90.
3. Structural Performance:
  - a. Casings shall be fabricated to withstand 133 percent of the indicated static pressure without structural failure. Wall and roof deflection at the indicated static pressure shall not exceed **1/8 inch per foot (0.97 mm per meter)** of width.
    - 1) Fabricate outdoor casings to withstand wind load of **15 lbf/sq. ft. (720 N/sq. m)** and snow load of **30 lbf/sq. ft. (1440 N/sq. m).**
4. Seismic Performance: HVAC casings shall withstand the effects of earthquake motions determined according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
  - b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
  - c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
  - d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-Up."
  - e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For HVAC casings. Include plans, elevations, sections, components, and attachments to other work.
4. Welding certificates.
5. Field quality-control reports.

## E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports **OR** AWS D9.1M/D9.1, "Sheet Metal Welding Code," for casing joint and seam welding, **as directed**.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

## 1.2 PRODUCTS

## A. General Casing Fabrication Requirements

1. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 6, "Equipment and Casings," for acceptable materials, material thicknesses, and casing construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
  - a. Fabricate casings with more than **3-inch wg (750-Pa)** negative static pressure according to SMACNA's "Rectangular Industrial Duct Construction Standards."
  - b. Casings with more than **2-inch wg (500-Pa)** positive static pressure may be fabricated according to SMACNA's "Rectangular Industrial Duct Construction Standards."
2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - a. Exterior Surface Galvanized Coating Designation: **G60 (Z180) OR G90 (Z275), as directed**.
  - b. Interior Surface Galvanized Coating Designation:
    - 1) Sections Not Exposed to Moisture: **G60 (Z180) OR G90 (Z275), as directed**.
    - 2) Sections Housing and Downstream from Cooling Coil and Humidifiers: **G90 (Z275)**.
3. Stainless Steel: ASTM A 480/A 480M, Type 304 **OR** Type 316, **as directed**, and having a No. 2D, **as directed**, finish.
4. Factory- or Shop-Applied Antimicrobial Coating:
  - a. Apply to the interior sheet metal surfaces of casing in contact with the airstream. Apply untreated clear coating to the exterior surface.
  - b. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
  - c. Coating containing the antimicrobial compound shall have a hardness of 2H minimum when tested according to ASTM D 3363.
  - d. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 according to UL 723; certified by an NRTL.
  - e. Applied Coating Color: Standard **OR** Black **OR** White, **as directed**.
5. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
6. Sealing Requirement: SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Seal Class A. Seal all seams, joints, connections, and abutments to building.
7. Penetrations: Seal all penetrations airtight. Cover with escutcheons and gaskets, or fill with suitable compound so there is no exposed insulation. Provide shaft seals where fan shafts penetrate casing.
8. Access Doors: Fabricate access doors according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 6-11, "Casing Access Doors - 2-inch wg (500 Pa)," and Figure 6.12, "Casing Access Doors - 3-10-inch wg (750-2500 Pa)"; and according to pressure class of the plenum or casing section in which access doors are to be installed.
  - a. Size: **20 by 54 inches (500 by 1370 mm)**.
  - b. Vision Panel: Double-glazed, wire-reinforced safety glass with an airspace between panes and sealed with interior and exterior rubber seals.
  - c. Hinges: Piano or butt hinges and latches, number and size according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."



- d. Latches: Minimum of two wedge-lever-type latches, operable from inside and outside.
- e. Neoprene gaskets around entire perimeters of door frames.
- f. Doors shall open against air pressure.
9. Condensate Drain Pans: Formed sections of Type 304, stainless-steel sheet **OR** G90 (Z275) coated, galvanized sheet steel, **as directed**, complying with requirements in ASHRAE 62.1. Pans shall extend a minimum of 12 inches (300 mm) past coil.
  - a. Double-wall construction shall have space between walls filled with foam insulation and sealed moisture tight.
  - b. Intermediate drain pan or drain trough shall collect condensate from top coil for units with stacked coils or stacked eliminators.
  - c. Insulation: Polystyrene or polyurethane.
  - d. Slopes shall be in a minimum of two planes to collect condensate from cooling coils (including coil piping connections and return bends), eliminators, and humidifiers when units are operating at maximum catalogued face velocity across cooling coil.
  - e. Each drain pan connection shall have a trap. Drain traps with depth and height differential between inlet and outlet equal or greater to the design static pressure plus 2-inch wg (500 Pa), **as directed**. Include slab height in trap calculation.
- B. Shop-Fabricated Casings
  1. Single- and Double-Wall Casings: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
  2. Double-Wall Casing Inner Panel: Perforated, galvanized sheet steel having 3/32-inch- (2.4-mm-) diameter perforations, with overall open area of 23 percent. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.  
**OR**  
Double-Wall Casing Inner Panel: Solid sheet steel. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for sheet metal thickness based on indicated static-pressure class unless otherwise indicated.
  3. Interstitial Insulation: Polyurethane foam complying with NFPA 90A or NFPA 90B.  
**OR**  
Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
    - a. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K) at 75 deg F (24 deg C) mean temperature.
    - b. Coat insulation with antimicrobial coating.
    - c. Cover insulation with polyester film complying with UL 181, Class 1.
  - OR**  
Interstitial Insulation: Flexible-elastomeric duct liner complying with ASTM C 534, Type II for sheet materials and with NFPA 90A or NFPA 90B.
    - a. Maximum Thermal Conductivity: 0.25 Btu x in./h x sq. ft. x deg F (0.034 W/m x K) at 75 deg F (24 deg C) mean temperature.
  4. Fabricate casings with standing seams and angle-iron reinforcements unless otherwise indicated.
  5. Fabricate close-off sheets from casing to dampers, filter frames, and coils and between stacked coils. Use galvanized sheet steel of same thickness as casing and with a galvanized coating designation of G90 (Z275).
  6. Bolt close-off sheets to frame flanges and housings. Support coils on stands fabricated from galvanized-steel angles or channels.
  7. Reinforce casings with galvanized-steel angles.
- C. Manufactured Casings
  1. Description: Double-wall, insulated, pressurized equipment casing.
  2. Double-Wall Panel Fabrication: Solid, galvanized sheet steel exterior wall and solid **OR** perforated, **as directed**, galvanized sheet steel interior wall; with space between wall filled with insulation.



- a. Wall Thickness: **2 inches (50 mm) OR 4 inches (100 mm), as directed.**
- b. Fabricate with a minimum number of joints.
- c. Weld exterior and interior walls to perimeter; to interior, longitudinal, galvanized-steel channels; and to box-end internal closures. Paint welds.
- d. Sheet metal thickness shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for static-pressure class indicated for casing.  
**OR**  
Sheet Metal Thicknesses:
  - 1) Exterior Wall Thickness: **0.040 inch (1.0 mm)** minimum.
  - 2) Interior Wall Thickness: **0.034 inch (0.85 mm)** minimum.
- e. Double-Wall Casing Inner Panel: Perforated, galvanized sheet steel having **3/32-inch-(2.4-mm-)** diameter perforations, with overall open area of 23 percent.  
**OR**  
Double-Wall Casing Inner Panel: Solid sheet steel.
- f. Fill each panel assembly with insulating material that is noncombustible, inert, mildew resistant and vermin proof and that complies with NFPA 90A.
- g. Fabricate panels with continuous tongue-and-groove **OR** self-locking, **as directed**, joints effective inside and outside each panel.
- 3. Trim Items: Fabricate from a minimum of **0.052-inch (1.3-mm)** galvanized sheet steel, furnished in standard lengths for field cutting.

#### D. Casing Liner

- 1. Fibrous-Glass Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
  - a. Maximum Thermal Conductivity:
    - 1) Type I, Flexible: **0.27 Btu x in./h x sq. ft. x deg F (0.039 W/m x K)** at **75 deg F (24 deg C)** mean temperature.
    - 2) Type II, Rigid: **0.23 Btu x in./h x sq. ft. x deg F (0.033 W/m x K)** at **75 deg F (24 deg C)** mean temperature.
  - b. Antimicrobial Erosion-Resistant Coating: Apply to surface of the liner that will form the interior surface of casing to act as a moisture repellent and an erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
  - c. Solvent **OR** Water, **as directed**, -Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
    - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 2. Flexible-Elastomeric Casing Liner: Preformed, cellular, closed-cell, sheet materials complying with ASTM C 534, Type II, Grade 1, and with NFPA 90A or NFPA 90B.
  - a. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
  - b. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
    - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 3. Natural-Fiber Casing Liner: 85 percent cotton, 10 percent borate, and 5 percent polybinding fibers, treated with a microbial growth inhibitor, and complying with NFPA 90A or NFPA 90B.
  - a. Maximum Thermal Conductivity: **0.24 Btu x in./h x sq. ft. x deg F (0.034 W/m x K)** at **75 deg F (24 deg C)** mean temperature when tested according to ASTM C 518.
  - b. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
  - c. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
    - 1) For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

4. Insulation Pins and Washers:
    - a. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, **0.106-inch- (2.6-mm-) OR 0.135-inch- (3.5-mm-)**, **as directed**, diameter shank, length to suit depth of insulation indicated with integral **1-1/2-inch (38-mm)** galvanized carbon-steel washer.
    - b. Insulation-Retaining Washers: Self-locking washers formed from **0.016-inch- (0.41-mm-)** thick, galvanized **OR** stainless, **as directed**, steel, with beveled edge sized as required to hold insulation securely in place but not less than **1-1/2 inches (38 mm)** in diameter.
  5. Shop or Factory Application of Casing Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
    - a. Adhere a single layer of indicated thickness of casing liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of casing liner is prohibited.
    - b. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
    - c. Butt transverse joints without gaps, and coat joint with adhesive.
    - d. Fold and compress liner in corners of casings or cut and fit to ensure butted-edge overlapping.
    - e. Apply adhesive coating on longitudinal seams in casings with air velocity of **2500 fpm (12.7 m/s)**.
    - f. Secure liner with mechanical fasteners **4 inches (100 mm)** from corners and at intervals not exceeding **12 inches (300 mm)** transversely; at **3 inches (75 mm)** from transverse joints and at intervals not exceeding **18 inches (450 mm)** longitudinally.
    - g. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from casing wall. Fabricate edge facings at the following locations:
      - 1) Fan discharges.
      - 2) Intervals of lined casing preceding unlined duct.
      - 3) Upstream edges of transverse joints in casings where air velocities are higher than **2500 fpm (12.7 m/s)** or where indicated.
    - h. Secure insulation between perforated sheet metal inner wall of same thickness as specified for outer wall. Use mechanical fasteners that maintain inner wall at uniform distance from outer wall without compressing insulation.
- E. Sealant Materials
1. General Sealant and Gasket Requirements: Surface-burning characteristics for sealants and gaskets shall be a maximum flame-spread index of 25 and a maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
  2. Water-Based Joint and Seam Sealant:
    - a. Application Method: Brush on.
    - b. Solids Content: Minimum 65 percent.
    - c. Shore A Hardness: Minimum 20.
    - d. Water resistant.
    - e. Mold and mildew resistant.
    - f. VOC: Maximum 75 g/L (less water).

**OR**

For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

    - g. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive or negative.
    - h. Service: Indoor or outdoor.
    - i. Substrate: Compatible with galvanized sheet steel or stainless steel.
  3. Solvent-Based Joint and Seam Sealant:
    - a. Application Method: Brush on.
    - b. Base: Synthetic rubber resin.
    - c. Solvent: Toluene and heptane.
    - d. Solids Content: Minimum 60 percent.



- e. Shore A Hardness: Minimum 60.
- f. Water resistant.
- g. Mold and mildew resistant.
- h. VOC: Maximum 395 g/L.
- OR**
- For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- i. Maximum Static-Pressure Class: **10-inch wg (2500 Pa)**, positive or negative.
- j. Service: Indoor or outdoor.
- k. Substrate: Compatible with galvanized sheet steel or stainless steel.
- 4. Flanged Joint Sealant: Comply with ASTM C 920.
  - a. General: Single component, acid curing, silicone, elastomeric.
  - b. Type: S.
  - c. Grade: NS.
  - d. Class: 25.
  - e. Use: O.
  - f. For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 5. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

### 1.3 EXECUTION

#### A. Installation

- 1. Install casings according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 2. Equipment Mounting: Install HVAC casings on concrete base. Comply with requirements for concrete base specified in Division 07 Section "Manufactured Roof Expansion Joints".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported casings, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
- 3. Install seismic restraints on casings. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment"
- 4. Apply sealant to joints, connections, and mountings.
- 5. Field-cut openings for pipe and conduit penetrations; insulate and seal according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- 6. Support casings on floor or foundation system. Secure and seal to base.
- 7. Support components rigidly with ties, braces, brackets, seismic restraints, **as directed**, and anchors of types that will maintain housing shape and prevent buckling.
- 8. Align casings accurately at connections, with **1/8-inch (3-mm)** misalignment tolerance and with smooth interior surfaces.

#### B. Field Quality Control

- 1. Tests and Inspections:
  - a. Perform field tests and inspections according to SMACNA's "HVAC Air Duct Leakage Test Manual."
  - b. Test the following systems:
    - 1) Systems required by ASHRAE/IESNA 90.1.
    - 2) Supply Air: 100 **OR** 50, **as directed**, percent of total installed duct area with a pressure class of **3-inch wg (750 Pa) OR 4-inch wg (1000 Pa)**, **as directed**, or higher.

- c. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
    - d. Determine leakage from entire system or section of system by relating leakage to surface area of test section. Comply with requirements for leakage classification of ducts connected to casings.
    - e. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  - 2. HVAC casings will be considered defective if they do not pass tests and inspections.
  - 3. Prepare test and inspection reports.
- C. Cleaning
- 1. Comply with requirements for cleaning in Division 23 Section "Metal Ducts".

END OF SECTION 23 31 13 13a

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## SECTION 23 31 13 16 - TAILPIPE EXHAUST EQUIPMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of tailpipe exhaust equipment. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Capacity and Performance

1. Based on standard air density (0.075 pound per cubic foot). Fans shall have a peak static efficiency of not less than 60 percent.

#### B. Blowers and Accessories

1. Comply with AMCA 210, 300, and 301. Fan impellers shall be constructed of heavy gauge steel and accurately balanced both statically and dynamically when installed in the assembled fan unit. Impeller and housing in the air stream shall be coated with neoprene, epoxy, phenolic resins, or other material suitable to resist the corrosive gases and temperatures encountered. Fans to be mounted on exterior of building shall be provided with weatherproof covers.

#### C. Exhaust Duct and Fittings for Vehicle Tailpipe Exhaust Systems

1. Constructed of galvanized sheet steel, conforming to ASTM A 525. Ductwork shall be constructed with minimum metal gauge thickness and reinforced as required in the SMACNA Duct Construction Standards - Metal and Flexible.
  - a. Tailpipe Adapter shall be not less than 20-gauge corrosion-resisting steel. The adapter shall be of the tapered cone type with spring clip or other suitable device for exhaust pipe attachment.
  - b. Flexible Exhaust Tubing shall be 0.012 minimum thickness galvanized sheet steel or heat-resistant, reinforced wire, fiberglass, and neoprene tubing.
  - c. Dampers shall be of the circular disk type with quadrant locking device or blast gate type.
  - d. A Flexible Tubing Suspension System shall be furnished and installed for repaired tailpipe exhaust systems where no such suspension system exists. The flexible tubing suspension system shall suspend the flexible tubing overhead when not in use, allowing it to be lowered to the operating level, when required. The suspension system installed shall be complete with cable, pulleys, and operating mechanism.

### 1.3 EXECUTION

- #### A. Ductwork joints in galvanized sheet steel ductwork shall be soldered or otherwise sealed. The lock seam in straight sections shall be located on top of the duct. Seams shall be suitable for 10-inch water gauge static pressure. Ductwork shall be constructed with minimum metal gauge thickness and reinforced as required in the SMACNA Duct Construction Standards - Metal and Flexible.

- #### B. Weather-Resistant Finishes of items located outdoors shall meet the requirements of ASTM B 117.



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Task	Specification	Specification Description
23 31 13 16	23 31 13 13	Metal Ducts
23 31 13 16	23 31 13 13a	HVAC Casings

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## SECTION 23 31 13 19 - DUCT ACCESSORIES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for duct accessories. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Backdraft and pressure relief dampers.
  - b. Barometric relief dampers.
  - c. Manual volume dampers.
  - d. Control dampers.
  - e. Fire dampers.
  - f. Ceiling dampers.
  - g. Smoke dampers.
  - h. Combination fire and smoke dampers.
  - i. Corridor dampers.
  - j. Flange connectors.
  - k. Duct silencers.
  - l. Turning vanes.
  - m. Remote damper operators.
  - n. Duct-mounted access doors.
  - o. Flexible connectors.
  - p. Flexible ducts.
  - q. Duct security bars.
  - r. Duct accessory hardware.

#### C. Submittals

1. Product Data: For each type of product indicated.
  - a. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.
2. LEED Submittal:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.
  - a. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:
    - 1) Special fittings.
    - 2) Manual volume damper installations.
    - 3) Control damper installations.
    - 4) Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
    - 5) Duct security bars.
    - 6) Wiring Diagrams: For power, signal, and control wiring.
4. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.

5. Source quality-control reports.
6. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

D. Quality Assurance

1. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."
2. Comply with AMCA 500-D testing for damper rating.

## 1.2 PRODUCTS

A. Materials

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
2. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
  - a. Galvanized Coating Designation: **G60 (Z180) OR G90 (Z275), as directed.**
  - b. Exposed-Surface Finish: Mill phosphatized.
3. Stainless-Steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and **<Insert finish designation>** finish for exposed ducts.
4. Aluminum Sheets: Comply with **ASTM B 209 (ASTM B 209M)**, Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
5. Extruded Aluminum: Comply with **ASTM B 221 (ASTM B 221M)**, Alloy 6063, Temper T6.
6. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
7. Tie Rods: Galvanized steel, **1/4-inch (6-mm)** minimum diameter for lengths **36 inches (900 mm)** or less; **3/8-inch (10-mm)** minimum diameter for lengths longer than **36 inches (900 mm)**.

B. Backdraft And Pressure Relief Dampers

1. Description: Gravity balanced.
2. Maximum Air Velocity: **2000 fpm (10 m/s) OR 3000 fpm (15 m/s), as directed.**
3. Maximum System Pressure: **1-inch wg (0.25 kPa) OR 2-inch wg (0.5 kPa), as directed.**
4. Frame: **0.052-inch- (1.3-mm-) thick, galvanized sheet steel OR 0.063-inch- (1.6-mm-) thick extruded aluminum OR 0.052-inch- (1.3-mm-) thick stainless steel, as directed,** with welded corners and mounting flange, **as directed.**
5. Blades: Multiple single-piece blades, center-pivoted, **as directed,** maximum **6-inch (150-mm)** width, **0.025-inch- (0.6-mm-) thick, roll-formed aluminum OR 0.050-inch- (1.2-mm-) thick aluminum sheet OR noncombustible, tear-resistant, neoprene-coated fiberglass, as directed,** with sealed edges.
6. Blade Action: Parallel.
7. Blade Seals: Felt **OR Vinyl foam OR Extruded vinyl, mechanically locked OR Neoprene, mechanically locked, as directed.**
8. Blade Axles:
  - a. Material: Nonferrous metal **OR Galvanized steel OR Plated steel OR Stainless steel OR Non-metallic OR Aluminum, as directed.**
  - b. Diameter: **0.20 inch (5 mm).**
9. Tie Bars and Brackets: Aluminum **OR Galvanized steel, as directed.**
10. Return Spring: Adjustable tension.
11. Bearings: Steel ball **OR Synthetic pivot bushings OR Steel ball or synthetic pivot bushings, as directed.**
12. Accessories:
  - a. Adjustment device to permit setting for varying differential static pressure.
  - b. Counterweights and spring-assist kits for vertical airflow installations.

- c. Electric actuators.
  - d. Chain pulls.
  - e. Screen Mounting: Front mounted in sleeve.
    - 1) Sleeve Thickness: 20-gage (1.0-mm) minimum.
    - 2) Sleeve Length: 6 inches (152 mm) minimum.
  - OR
  - Screen Mounting: Rear mounted.
  - f. Screen Material: Galvanized steel OR Aluminum, as directed.
  - g. Screen Type: Bird OR Insect, as directed.
  - h. 90-degree stops.
- C. Barometric Relief Dampers
- 1. Suitable for horizontal or vertical mounting.
  - 2. Maximum Air Velocity: 2000 fpm (10 m/s) OR 2500 fpm (13 m/s), as directed.
  - 3. Maximum System Pressure: 2-inch wg (0.5 kPa).
  - 4. Frame: 0.064-inch- (1.6-mm-) thick, galvanized sheet steel OR 0.063-inch- (1.6-mm-) thick extruded aluminum, as directed, with welded corners and mounting flange, as directed.
  - 5. Blades:
    - a. Multiple, 0.025-inch- (0.6-mm-) thick, roll-formed aluminum OR 0.050-inch- (1.2-mm-) thick aluminum sheet, as directed.
    - b. Maximum Width: 6 inches (150 mm).
    - c. Action: Parallel.
    - d. Balance: Gravity.
    - e. Eccentrically pivoted.
  - 6. Blade Seals: Vinyl OR Neoprene, as directed.
  - 7. Blade Axles: Galvanized steel OR Nonferrous metal, as directed.
  - 8. Tie Bars and Brackets:
    - a. Material: Aluminum OR Galvanized steel, as directed.
    - b. Rattle free with 90-degree stop.
  - 9. Return Spring: Adjustable tension.
  - 10. Bearings: Synthetic OR Stainless steel OR Bronze, as directed.
  - 11. Accessories:
    - a. Flange on intake.
    - b. Adjustment device to permit setting for varying differential static pressures.
- D. Manual Volume Dampers
- 1. Standard, Steel, Manual Volume Dampers:
    - a. Standard leakage rating, with linkage outside airstream, as directed.
    - b. Suitable for horizontal or vertical applications.
    - c. Frames:
      - 1) Hat-shaped, galvanized-steel OR stainless-steel, as directed, channels, 0.064-inch (1.62-mm) minimum thickness.
      - 2) Mitered and welded corners.
      - 3) Flanges for attaching to walls and flangeless frames for installing in ducts.
    - d. Blades:
      - 1) Multiple or single blade.
      - 2) Parallel- or opposed-blade design.
      - 3) Stiffen damper blades for stability.
      - 4) Galvanized-steel OR Stainless-steel, as directed, 0.064 inch (1.62 mm) thick.
    - e. Blade Axles: Galvanized steel OR Stainless steel OR Nonferrous metal, as directed.
    - f. Bearings:
      - 1) Oil-impregnated bronze OR Molded synthetic OR Stainless-steel sleeve, as directed.
      - 2) Dampers in ducts with pressure classes of 3-inch wg (750 Pa) or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
    - g. Tie Bars and Brackets: Galvanized steel.

2. Standard, Aluminum, Manual Volume Dampers:
  - a. Standard leakage rating, with linkage outside airstream, **as directed**.
  - b. Suitable for horizontal or vertical applications.
  - c. Frames: Hat-shaped, **0.10-inch- (2.5-mm-)** thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
  - d. Blades:
    - 1) Multiple or single blade.
    - 2) Parallel- or opposed-blade design.
    - 3) Stiffen damper blades for stability.
    - 4) Roll-Formed Aluminum Blades: **0.10-inch- (2.5-mm-)** thick aluminum sheet.  
**OR**  
Extruded-Aluminum Blades: **0.050-inch- (1.2-mm-)** thick extruded aluminum.
  - e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
  - f. Bearings:
    - 1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
    - 2) Dampers in ducts with pressure classes of **3-inch wg (750 Pa)** or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
  - g. Tie Bars and Brackets: Aluminum.
3. Low-Leakage, Steel, Manual Volume Dampers:
  - a. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
  - b. Suitable for horizontal or vertical applications.
  - c. Frames:
    - 1) Hat **OR** U **OR** Angle, **as directed**, shaped.
    - 2) Galvanized-steel **OR** Stainless-steel, **as directed**, channels, **0.064 inch (1.62 mm)** thick.
    - 3) Mitered and welded corners.
    - 4) Flanges for attaching to walls and flangeless frames for installing in ducts.
  - d. Blades:
    - 1) Multiple or single blade.
    - 2) Parallel- or opposed-blade design.
    - 3) Stiffen damper blades for stability.
    - 4) Galvanized **OR** Stainless, **as directed**, roll-formed steel, **0.064 inch (1.62 mm)** thick.
  - e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
  - f. Bearings:
    - 1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
    - 2) Dampers in ducts with pressure classes of **3-inch wg (750 Pa)** or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
  - g. Blade Seals: Felt **OR** Vinyl **OR** Neoprene, **as directed**.
  - h. Jamb Seals: Cambered stainless steel **OR** aluminum, **as directed**.
  - i. Tie Bars and Brackets: Galvanized steel **OR** Aluminum, **as directed**.
  - j. Accessories:
    - 1) Include locking device to hold single-blade dampers in a fixed position without vibration.
4. Low-Leakage, Aluminum, Manual Volume Dampers:
  - a. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
  - b. Suitable for horizontal or vertical applications.
  - c. Frames: Hat **OR** U **OR** Angle, **as directed**, -shaped, **0.10-inch- (2.5-mm-)** thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
  - d. Blades:
    - 1) Multiple or single blade.

- 2) Parallel- or opposed-blade design.
- 3) Roll-Formed Aluminum Blades: **0.10-inch- (2.5-mm-)** thick aluminum sheet.  
**OR**  
Extruded-Aluminum Blades: **0.050-inch- (1.2-mm-)** thick extruded aluminum.
- e. Blade Axles: Galvanized steel **OR** Stainless steel **OR** Nonferrous metal, **as directed**.
- f. Bearings:
  - 1) Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
  - 2) Dampers in ducts with pressure classes of **3-inch wg (750 Pa)** or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
- g. Blade Seals: Felt **OR** Vinyl **OR** Neoprene, **as directed**.
- h. Jamb Seals: Cambered stainless steel **OR** aluminum, **as directed**.
- i. Tie Bars and Brackets: Galvanized steel **OR** Aluminum, **as directed**.
- j. Accessories:
  - 1) Include locking device to hold single-blade dampers in a fixed position without vibration.
5. Jackshaft:
  - a. Size: **1-inch (25-mm)** diameter.
  - b. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.
  - c. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.
6. Damper Hardware:
  - a. Zinc-plated, die-cast core with dial and handle made of **3/32-inch- (2.4-mm-)** thick zinc-plated steel, and a **3/4-inch (19-mm)** hexagon locking nut.
  - b. Include center hole to suit damper operating-rod size.
  - c. Include elevated platform for insulated duct mounting.
- E. Control Dampers
  1. Low-leakage rating, with linkage outside airstream, **as directed**, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage.
  2. Frames:
    - a. Hat **OR** U **OR** Angle, **as directed**, shaped.
    - b. Galvanized-steel **OR** Stainless-steel, **as directed**, channels, **0.064 inch (1.62 mm)** thick.
    - c. Mitered and welded corners.
  3. Blades:
    - a. Multiple blade with maximum blade width of **8 inches (200 mm)**.
    - b. Parallel **OR** Parallel- and opposed **OR** Opposed, **as directed**, -blade design.
    - c. Galvanized **OR** Stainless, **as directed**, steel.
    - d. **0.064 inch (1.62 mm)** thick.
    - e. Blade Edging: Closed-cell neoprene edging.  
**OR**  
Blade Edging: Inflatable seal blade edging, or replaceable rubber seals.
  4. Blade Axles: **1/2-inch- (13-mm-)** diameter; galvanized steel **OR** stainless steel **OR** nonferrous metal, **as directed**; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.
    - a. Operating Temperature Range: From **minus 40 to plus 200 deg F (minus 40 to plus 93 deg C)**.
  5. Bearings:
    - a. Oil-impregnated bronze **OR** Molded synthetic **OR** Stainless-steel sleeve, **as directed**.
    - b. Dampers in ducts with pressure classes of **3-inch wg (750 Pa)** or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
    - c. Thrust bearings at each end of every blade.
- F. Fire Dampers



1. Type: Static **OR** Dynamic **OR** Static and dynamic, **as directed**; rated and labeled according to UL 555 by an NRTL.
2. Closing rating in ducts up to **4-inch wg (1-kPa)** static pressure class and minimum **4000-fpm (20-m/s)** velocity.
3. Fire Rating: 1-1/2 **OR** 3, **as directed**, hours.
4. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, **0.034-inch- (0.85-mm-)** thick galvanized steel; with mitered and interlocking corners.
5. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
  - a. Minimum Thickness: **0.052 or 0.138 inch (1.3 or 3.5 mm)** thick, as indicated, and of length to suit application.
  - b. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
6. Mounting Orientation: Vertical or horizontal as indicated.
7. Blades: Roll-formed, interlocking, **0.034-inch- (0.85-mm-)** thick, galvanized sheet steel. In place of interlocking blades, use full-length, **0.034-inch- (0.85-mm-)** thick, galvanized-steel blade connectors.
8. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
9. Heat-Responsive Device: Replaceable, **165 deg F (74 deg C) OR 212 deg F (100 deg C)**, **as directed**, rated, fusible links.  
**OR**  
Heat-Responsive Device: Electric **OR** Pneumatic, **as directed**, resettable link and switch package, factory installed, **165 deg F (74 deg C) OR 212 deg F (100 deg C)**, **as directed**, rated.

#### G. Ceiling Dampers

1. General Requirements:
  - a. Labeled according to UL 555C by an NRTL.
  - b. Comply with construction details for tested floor- and roof-ceiling assemblies as indicated in UL's "Fire Resistance Directory."
2. Frame: Galvanized sheet steel, round or rectangular, style to suit ceiling construction.
3. Blades: Galvanized sheet steel with refractory insulation.
4. Heat-Responsive Device: Replaceable, **165 deg F (74 deg C) OR 212 deg F (100 deg C)**, **as directed**, rated, fusible links.
5. Fire Rating: 2 **OR** 3, **as directed**, hours.

#### H. Smoke Dampers

1. General Requirements: Label according to UL 555S by an NRTL.
2. Smoke Detector: Integral, factory wired for single-point connection.
3. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, **0.034-inch- (0.85-mm-)** thick galvanized steel; with mitered and interlocking corners.
4. Blades: Roll-formed, horizontal, interlocking, **0.034-inch- (0.85-mm-)** thick, galvanized sheet steel. In place of interlocking blades, use full-length, **0.034-inch- (0.85-mm-)** thick, galvanized-steel blade connectors.
5. Leakage: Class I **OR** Class II, **as directed**.
6. Rated pressure and velocity to exceed design airflow conditions.
7. Mounting Sleeve: Factory-installed, **0.052-inch- (1.3-mm-)** thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking, **as directed**.
8. Damper Motors: Modulating **OR** Two-position, **as directed**, action.
9. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".

- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section(s) "Instrumentation And Control For Hvac" OR Division 22, **as directed**.
- c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
- d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of **150 in. x lbf (17 N x m)** and breakaway torque rating of **150 in. x lbf (17 N x m)**.
- e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at **minus 40 deg F (minus 40 deg C)**.
- f. Nonspring-Return Motors: For dampers larger than **25 sq. ft. (2.3 sq. m)**, size motor for running torque rating of **150 in. x lbf (17 N x m)** and breakaway torque rating of **300 in. x lbf (34 N x m)**.
- g. Electrical Connection: 115 V, single phase, 60 Hz.
10. Accessories:
  - a. Auxiliary switches for signaling **OR** fan control **OR** position indication, **as directed**.
  - b. Momentary test switch **OR** Test and reset switches, **as directed**, damper **OR** remote, **as directed**, mounted.
- I. Combination Fire And Smoke Dampers
  1. Type: Static **OR** Dynamic **OR** Static and dynamic, **as directed**; rated and labeled according to UL 555 and UL 555S by an NRTL.
  2. Closing rating in ducts up to **4-inch wg (1-kPa)** static pressure class and minimum **4000-fpm (20-m/s)** velocity.
  3. Fire Rating: 1-1/2 **OR** 3, **as directed**, hours.
  4. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, **0.034-inch- (0.85-mm-)** thick galvanized steel; with mitered and interlocking corners.
  5. Heat-Responsive Device: Replaceable, **165 deg F (74 deg C)** **OR** **212 deg F (100 deg C)**, **as directed**, rated, fusible links.  
**OR**  
Heat-Responsive Device: Electric **OR** Pneumatic, **as directed**, resettable link and switch package, factory installed, rated.
  6. Smoke Detector: Integral, factory wired for single-point connection.
  7. Frame: Curtain type with blades inside airstream **OR** Curtain type with blades outside airstream **OR** Multiple-blade type **OR** Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, **0.034-inch- (0.85-mm-)** thick galvanized steel; with mitered and interlocking corners.
  8. Blades: Roll-formed, horizontal, interlocking, **0.034-inch- (0.85-mm-)** thick, galvanized sheet steel. In place of interlocking blades, use full-length, **0.034-inch- (0.85-mm-)** thick, galvanized-steel blade connectors.
  9. Leakage: Class I **OR** Class II, **as directed**.
  10. Rated pressure and velocity to exceed design airflow conditions.
  11. Mounting Sleeve: Factory-installed, **0.052-inch- (1.3-mm-)** thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone calking, **as directed**.
  12. Master control panel for use in dynamic smoke-management systems.
  13. Damper Motors: Modulating **OR** Two-position, **as directed**, action.
  14. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".



- a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
- b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section(s) "Instrumentation And Control For Hvac" OR Division 22, **as directed**.
- c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
- d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).
- e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F (minus 40 deg C).
- f. Nonspring-Return Motors: For dampers larger than 25 sq. ft. (2.3 sq. m), size motor for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 300 in. x lbf (34 N x m).
- g. Electrical Connection: 115 V, single phase, 60 Hz.
- 15. Accessories:
  - a. Auxiliary switches for signaling OR fan control OR position indication, **as directed**.
  - b. Momentary test switch OR Test and reset switches, **as directed**, damper OR remote, **as directed**, mounted.

J. Corridor Dampers

- 1. General Requirements: Label combination fire and smoke dampers according to UL 555 for 1-1/2-hour rating by an NRTL.
- 2. Heat-Responsive Device: Replaceable, 165 deg F (74 deg C) OR 212 deg F (100 deg C), **as directed**, rated, fusible links.  
**OR**  
Heat-Responsive Device: Electric OR Pneumatic, **as directed**, resettable link and switch package, factory installed, rated.
- 3. Frame: Curtain type with blades inside airstream OR Curtain type with blades outside airstream OR Multiple-blade type OR Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream, **as directed**; fabricated with roll-formed, 0.034-inch- (0.85-mm-) thick galvanized steel; with mitered and interlocking corners.
- 4. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- (0.85-mm-) thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- (0.85-mm-) thick, galvanized-steel blade connectors.
- 5. Mounting Sleeve: Factory-installed, 0.052-inch- (1.3-mm-) thick, galvanized sheet steel; length to suit wall or floor application.
- 6. Damper Motors: Modulating OR Two-position, **as directed**, action.
- 7. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 23 Section(s) "Instrumentation And Control For Hvac" OR Division 22, **as directed**.
  - c. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
  - d. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf (17 N x m) and breakaway torque rating of 150 in. x lbf (17 N x m).

- e. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at **minus 40 deg F (minus 40 deg C)**.
  - f. Nonspring-Return Motors: For dampers larger than **25 sq. ft. (2.3 sq. m)**, size motor for running torque rating of **150 in. x lbf (17 N x m)** and breakaway torque rating of **300 in. x lbf (34 N x m)**.
  - g. Electrical Connection: 115 V, single phase, 60 Hz.
- K. Flange Connectors
1. Description: Add-on **OR** Roll-formed, **as directed**, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
  2. Material: Galvanized steel.
  3. Gage and Shape: Match connecting ductwork.
- L. Duct Silencers
1. General Requirements:
    - a. Factory fabricated.
    - b. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
    - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  2. Shape:
    - a. Rectangular straight with splitters or baffles.
    - b. Round straight with center bodies or pods.
    - c. Rectangular elbow with splitters or baffles.
    - d. Round elbow with center bodies or pods.
    - e. Rectangular transitional with splitters or baffles.
  3. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, **G90 (Z275) OR G60 (Z180), as directed**, galvanized sheet steel, **0.034 inch (0.85 mm) OR 0.040 inch (1.02 mm), as directed**, thick.
  4. Round Silencer Outer Casing: ASTM A 653/A 653M, **G90 (Z275) OR G60 (Z180), as directed**, galvanized sheet steel.
    - a. Sheet Metal Thickness for Units up to **24 Inches (600 mm)** in Diameter: **0.034 inch (0.85 mm)** thick.
    - b. Sheet Metal Thickness for Units **26 through 40 Inches (660 through 1000 mm)** in Diameter: **0.040 inch (1.02 mm)** thick.
    - c. Sheet Metal Thickness for Units **42 through 52 Inches (1060 through 1300 mm)** in Diameter: **0.052 inch (1.3 mm)** thick.
    - d. Sheet Metal Thickness for Units **54 through 60 Inches (1370 through 1500 mm)** in Diameter: **0.064 inch (1.62 mm)** thick.
  5. Inner Casing and Baffles: ASTM A 653/A 653M, **G90 (Z275) OR G60 (Z180), as directed**, galvanized sheet metal, **0.034 inch (0.85 mm)** thick, and with **1/8-inch- (3-mm-)** diameter perforations.
  6. Special Construction:
    - a. Suitable for outdoor use.
    - b. High transmission loss to achieve STC 45, **as directed**.
  7. Connection Sizes: Match connecting ductwork unless otherwise indicated.
  8. Principal Sound-Absorbing Mechanism:
    - a. Controlled impedance membranes and broadly tuned resonators without absorptive media.
    - b. Dissipative **OR** Film-lined, **as directed**, type with fill material.
      - 1) Fill Material: Inert and vermin-proof fibrous material, packed under not less than 5 percent compression **OR** Inert and vermin-proof fibrous material, packed under not less than 15 percent compression **OR** Moisture-proof nonfibrous material, **as directed**.
      - 2) Erosion Barrier: Polymer bag enclosing fill, and heat sealed before assembly.

- c. Lining: None **OR** Mylar **OR** Tedlar **OR** Fiberglass cloth, **as directed**.
  - 9. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
    - a. Lock form and seal or continuously weld joints **OR** Flange connections, **as directed**.
    - b. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
    - c. Reinforcement: Cross or trapeze angles for rigid suspension.
  - 10. Accessories:
    - a. Integral 1-1/2 **OR** 3, **as directed**,-hour fire damper with access door. Access door to be high transmission loss to match silencer, **as directed**.
    - b. Factory-installed end caps to prevent contamination during shipping.
    - c. Removable splitters.
    - d. Airflow measuring devices.
    - e. Source Quality Control: Test according to ASTM E 477.
    - f. Testing to be witnessed by the Owner.
    - g. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least **2000-fpm (10-m/s)** face velocity.
    - h. Leak Test: Test units for airtightness at 200 percent of associated fan static pressure or **6-inch wg (1500-Pa)** static pressure, whichever is greater.
- M. Turning Vanes
- 1. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
    - a. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.
  - 2. Manufactured Turning Vanes for Nonmetal Ducts: Fabricate curved blades of resin-bonded fiberglass with acrylic polymer coating; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
  - 3. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vanes and Vane Runners," and 2-4, "Vane Support in Elbows."
  - 4. Vane Construction: Single **OR** Double, **as directed**, wall.  
**OR**  
 Vane Construction: Single wall for ducts up to **48 inches (1200 mm)** wide and double wall for larger dimensions.
- N. Remote Damper Operators
- 1. Description: Cable system designed for remote manual damper adjustment.
  - 2. Tubing: Brass.
  - 3. Cable: Stainless steel.
  - 4. Wall-Box Mounting: Recessed, **3/4 inches (19 mm)** deep **OR** Recessed, **2 inches (50 mm)** deep **OR** Surface, **as directed**.
  - 5. Wall-Box Cover-Plate Material: Steel **OR** Stainless steel, **as directed**.
- O. Duct-Mounted Access Doors
- 1. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - Round Duct."
    - a. Door:
      - 1) Double wall, rectangular.
      - 2) Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
      - 3) Vision panel.
      - 4) Hinges and Latches: **1-by-1-inch (25-by-25-mm)** butt or piano hinge and cam latches.
      - 5) Fabricate doors airtight and suitable for duct pressure class.



- b. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
- c. Number of Hinges and Locks:
  - 1) Access Doors Less Than **12 Inches (300 mm)** Square: No hinges and two sash locks.
  - 2) Access Doors up to **18 Inches (460 mm)** Square: Two hinges and two sash locks.
  - 3) Access Doors up to **24 by 48 Inches (600 by 1200 mm)**: Three hinges and two compression latches with outside and inside handles, **as directed**.
  - 4) Access Doors Larger Than **24 by 48 Inches (600 by 1200 mm)**: Four hinges and two compression latches with outside and inside handles.
2. Pressure Relief Access Door:
  - a. Door and Frame Material: Galvanized sheet steel.
  - b. Door: Single wall **OR** Double wall with insulation fill, **as directed**, with metal thickness applicable for duct pressure class.
  - c. Operation: Open outward for positive-pressure ducts and inward for negative-pressure ducts.
  - d. Factory set at **10-inch wg (2500 Pa)**.
  - e. Doors close when pressures are within set-point range.
  - f. Hinge: Continuous piano.
  - g. Latches: Cam.
  - h. Seal: Neoprene or foam rubber.
  - i. Insulation Fill: **1-inch- (25-mm-)** thick, fibrous-glass or polystyrene-foam board.
- P. Duct Access Panel Assemblies
  1. Labeled according to UL 1978 by an NRTL.
  2. Panel and Frame: Minimum thickness **0.0528-inch (1.3-mm)** carbon **OR 0.0428-inch (1.1-mm)** stainless, **as directed**, steel.
  3. Fasteners: Carbon **OR** Stainless, **as directed**, steel. Panel fasteners shall not penetrate duct wall.
  4. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum **2000 deg F (1093 deg C)**.
  5. Minimum Pressure Rating: **10-inch wg (2500 Pa)**, positive or negative.
- Q. Flexible Connectors
  1. Materials: Flame-retardant or noncombustible fabrics.
  2. Coatings and Adhesives: Comply with UL 181, Class 1.
  3. Metal-Edged Connectors: Factory fabricated with a fabric strip **3-1/2 inches (89 mm)** **OR 5-3/4 inches (146 mm)**, **as directed**, wide attached to 2 strips of **2-3/4-inch- (70-mm-)** wide, **0.028-inch- (0.7-mm-)** thick, galvanized sheet steel or **0.032-inch- (0.8-mm-)** thick aluminum sheets. Provide metal compatible with connected ducts.
  4. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
    - a. Minimum Weight: **26 oz./sq. yd. (880 g/sq. m)**.
    - b. Tensile Strength: **480 lbf/inch (84 N/mm)** in the warp and **360 lbf/inch (63 N/mm)** in the filling.
    - c. Service Temperature: **Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C)**.
  5. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
    - a. Minimum Weight: **24 oz./sq. yd. (810 g/sq. m)**.
    - b. Minimum Tensile Strength: **500 lbf/inch (88 N/mm)** in the warp and **440 lbf/inch (77 N/mm)** in the filling.
    - c. Service Temperature: **Minus 50 to plus 250 deg F (Minus 45 to plus 121 deg C)**.
  6. High-Temperature System, Flexible Connectors: Glass fabric coated with silicone rubber.
    - a. Minimum Weight: **16 oz./sq. yd. (542 g/sq. m)**.
    - b. Tensile Strength: **285 lbf/inch (50 N/mm)** in the warp and **185 lbf/inch (32 N/mm)** in the filling.
    - c. Service Temperature: **Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C)**.

7. High-Corrosive-Environment System, Flexible Connectors: Glass fabric with chemical-resistant coating.
  - a. Minimum Weight: 14 oz./sq. yd. (474 g/sq. m).
  - b. Tensile Strength: 450 lbf/inch (79 N/mm) in the warp and 340 lbf/inch (60 N/mm) in the filling.
  - c. Service Temperature: Minus 67 to plus 500 deg F (Minus 55 to plus 260 deg C).
8. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
  - a. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
  - b. Outdoor Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - c. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
  - f. Elastomeric Element: Molded, oil-resistant rubber or neoprene.
  - g. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch (6-mm) movement at start and stop.

R. Flexible Ducts

1. Noninsulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire.
  - a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
  - b. Maximum Air Velocity: 4000 fpm (20 m/s).
  - c. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
2. Noninsulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire.
  - a. Pressure Rating: 4-inch wg (1000 Pa) positive and 0.5-inch wg (125 Pa) negative.
  - b. Maximum Air Velocity: 4000 fpm (20 m/s).
  - c. Temperature Range: Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C).
3. Noninsulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire.
  - a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
  - b. Maximum Air Velocity: 4000 fpm (20 m/s).
  - c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
4. Noninsulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire.
  - a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
  - b. Maximum Air Velocity: 4000 fpm (20 m/s).
  - c. Temperature Range: Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C).
5. Noninsulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil.
  - a. Pressure Rating: 8-inch wg (2280 Pa) positive or negative.
  - b. Maximum Air Velocity: 5000 fpm (25 m/s).
  - c. Temperature Range: Minus 100 to plus 435 deg F (Minus 73 to plus 224 deg C).
6. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
  - a. Pressure Rating: 10-inch wg (2500 Pa) positive and 1.0-inch wg (250 Pa) negative.
  - b. Maximum Air Velocity: 4000 fpm (20 m/s).
  - c. Temperature Range: Minus 10 to plus 160 deg F (Minus 23 to plus 71 deg C).
  - d. Insulation R-value: Comply with ASHRAE/IESNA 90.1.
7. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.



- a. Pressure Rating: **4-inch wg (1000 Pa)** positive and **0.5-inch wg (125 Pa)** negative.
  - b. Maximum Air Velocity: **4000 fpm (20 m/s)**.
  - c. Temperature Range: **Minus 20 to plus 175 deg F (Minus 29 to plus 79 deg C)**.
  - d. Insulation R-Value: Comply with ASHRAE/IESNA 90.1.
8. Insulated, Flexible Duct: UL 181, Class 1, multiple layers of aluminum laminate supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
  - a. Pressure Rating: **10-inch wg (2500 Pa)** positive and **1.0-inch wg (250 Pa)** negative.
  - b. Maximum Air Velocity: **4000 fpm (20 m/s)**.
  - c. Temperature Range: **Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C)**.
  - d. Insulation R-value: Comply with ASHRAE/IESNA 90.1.
9. Insulated, Flexible Duct: UL 181, Class 1, aluminum laminate and polyester film with latex adhesive supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
  - a. Pressure Rating: **10-inch wg (2500 Pa)** positive and **1.0-inch wg (250 Pa)** negative.
  - b. Maximum Air Velocity: **4000 fpm (20 m/s)**.
  - c. Temperature Range: **Minus 20 to plus 210 deg F (Minus 29 to plus 99 deg C)**.
  - d. Insulation R-value: Comply with ASHRAE/IESNA 90.1.
10. Insulated, Flexible Duct: UL 181, Class 0, interlocking spiral of aluminum foil; fibrous-glass insulation; polyethylene **OR** aluminized, **as directed**, vapor-barrier film.
  - a. Pressure Rating: **8-inch wg (2280 Pa)** positive or negative.
  - b. Maximum Air Velocity: **5000 fpm (25 m/s)**.
  - c. Temperature Range: **Minus 20 to plus 250 deg F (Minus 29 to plus 121 deg C)**.
  - d. Insulation R-value: Comply with ASHRAE/IESNA 90.1.
11. Flexible Duct Connectors:
  - a. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action **OR** Nylon strap, **as directed**, in sizes **3 through 18 inches (75 through 460 mm)**, to suit duct size.
  - b. Non-Clamp Connectors: Adhesive **OR** Liquid adhesive plus tape **OR** Adhesive plus sheet metal screws, **as directed**.
- S. Duct Security Bars
  1. Description: Field-fabricated **OR** Factory-fabricated and field-installed **OR** Field- or factory-fabricated and field-installed, **as directed**, duct security bars.
  2. Configuration:
    - a. Frame: **10 gage by 2 inches (3.57 mm by 50 mm)**.
    - b. Sleeve: **3/16-inch (4.8-mm)**, continuously welded **OR** bent, **as directed**, steel frames with **1-by-1-by-3/16-inch (25-by-25-by-4.8-mm)** angle frame factory welded to 1 end **OR** furnished loose for field welding on other end, **as directed**. To be poured in place or set with concrete block or welded or bolted to wall, one side only. Duct connections on both sides.
    - c. Horizontal Bars: **1/2 inch (13 mm) OR 2 by 1/4 inch (50 by 6 mm)**, **as directed**.
    - d. Vertical Bars: **1/2 inch (13 mm) OR 3/4 inch (19 mm) OR 1 inch (25 mm)**, **as directed**.
    - e. Bar Spacing: **6 inches (150 mm)**.
    - f. Mounting: Metal deck or roofing **OR** Bolted or welded **OR** Bolted or welded with masonry anchors **OR** Ductwork or other framing **OR** Poured in place or set with concrete block **OR** Welded or bolted to one wall (one side only) **OR** Bar extends **6 inches (150 mm)** into wall, **as directed**.
- T. Duct Accessory Hardware
  1. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct-insulation thickness.
  2. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

### 1.3 EXECUTION

#### A. Installation

1. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
2. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
3. Install backdraft **OR** control, **as directed**, dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
4. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
  - a. Install steel volume dampers in steel ducts.
  - b. Install aluminum volume dampers in aluminum ducts.
5. Set dampers to fully open position before testing, adjusting, and balancing.
6. Install test holes at fan inlets and outlets and elsewhere as indicated.
7. Install fire and smoke, **as directed**, dampers according to UL listing.
8. Install duct security bars. Construct duct security bars from **0.164-inch (4.18-mm)** steel sleeve, continuously welded at all joints and **1/2-inch- (13-mm-)** diameter steel bars, **6 inches (150 mm)** o.c. in each direction in center of sleeve. Weld each bar to steel sleeve and each crossing bar. Weld **2-1/2-by-2-1/2-by-1/4-inch (63-by-63-by-6-mm)** steel angle to 4 sides and both ends of sleeve. Connect duct security bars to ducts with flexible connections. Provide **12-by-12-inch (300-by-300-mm)** hinged access panel with cam lock in duct in each side of sleeve.
9. Connect ducts to duct silencers with flexible duct connectors **OR** rigidly, **as directed**.
10. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
  - a. On both sides of duct coils.
  - b. Upstream **OR** Upstream and downstream, **as directed**, from duct filters.
  - c. At outdoor-air intakes and mixed-air plenums.
  - d. At drain pans and seals.
  - e. Downstream from manual volume dampers, control dampers, backdraft dampers, and equipment.
  - f. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
  - g. At each change in direction and at maximum **50-foot (15-m)** spacing.
  - h. Upstream **OR** Upstream and downstream, **as directed**, from turning vanes.
  - i. Upstream or downstream from duct silencers.
  - j. Control devices requiring inspection.
  - k. Elsewhere as indicated.
11. Install access doors with swing against duct static pressure.
12. Access Door Sizes:
  - a. One-Hand or Inspection Access: **8 by 5 inches (200 by 125 mm)**.
  - b. Two-Hand Access: **12 by 6 inches (300 by 150 mm)**.
  - c. Head and Hand Access: **18 by 10 inches (460 by 250 mm)**.
  - d. Head and Shoulders Access: **21 by 14 inches (530 by 355 mm)**.
  - e. Body Access: **25 by 14 inches (635 by 355 mm)**.
  - f. Body plus Ladder Access: **25 by 17 inches (635 by 430 mm)**.
13. Label access doors according to Division 21 Section "Fire-suppression Systems Insulation" to indicate the purpose of access door.
14. Install flexible connectors to connect ducts to equipment.

15. For fans developing static pressures of **5-inch wg (1250 Pa)** and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
16. Connect terminal units to supply ducts directly or, **as directed**, with maximum **12-inch (300-mm)** lengths of flexible duct. Do not use flexible ducts to change directions.
17. Connect diffusers or light troffer boots to ducts directly or, **as directed**, with maximum **60-inch (1500-mm)** lengths of flexible duct clamped or strapped in place.
18. Connect flexible ducts to metal ducts with adhesive **OR** liquid adhesive plus tape **OR** draw bands **OR** adhesive plus sheet metal screws, **as directed**.
19. Install duct test holes where required for testing and balancing purposes.
20. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of **1/4-inch (6-mm)** movement during start and stop of fans.

B. Field Quality Control

1. Tests and Inspections:
  - a. Operate dampers to verify full range of movement.
  - b. Inspect locations of access doors and verify that purpose of access door can be performed.
  - c. Operate fire, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
  - d. Inspect turning vanes for proper and secure installation.
  - e. Operate remote damper operators to verify full range of movement of operator and damper.

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Task	Specification	Specification Description
23 31 13 19	23 31 13 13	Metal Ducts
23 31 13 19	23 31 13 13a	HVAC Casings
23 31 13 23	23 31 13 13	Metal Ducts
23 31 13 23	23 31 13 13a	HVAC Casings

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## SECTION 23 31 16 13 - NONMETAL DUCTS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for nonmetal ducts. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Fibrous-glass ducts and fittings.
  - b. Phenolic-foam ducts and fittings.
  - c. Thermoset FRP ducts and fittings.
  - d. PVC ducts and fittings.

#### C. Performance Requirements

1. Delegated Duct Design: Duct construction, including duct closure, reinforcements, and hangers and supports, shall comply with SMACNA's "Fibrous Glass Duct Construction Standards" and performance requirements and design criteria indicated.
  - a. Static-Pressure Classes:
    - 1) Supply Ducts (except in Mechanical Rooms): 1-inch wg (250 Pa).
    - 2) Supply Ducts (Upstream from Air Terminal Units): 2-inch wg (500 Pa).
    - 3) Supply Ducts (Downstream from Air Terminal Units): 1-inch wg (250 Pa).
    - 4) Supply Ducts (in Mechanical Equipment Rooms): 2-inch wg (500 Pa).
    - 5) Return Ducts (Negative Pressure): 1-inch wg (250 Pa).
    - 6) Exhaust Ducts (Negative Pressure): 1-inch wg (250 Pa).
2. Structural Performance: Duct hangers and supports and seismic restraints, **as directed**, shall withstand the effects of gravity and seismic, **as directed**, loads and stresses within limits and under conditions to comply with ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
  - a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.  
**OR**  
Seismic Hazard Level B: Seismic force to weight ratio, 0.30.  
**OR**  
Seismic Hazard Level C: Seismic force to weight ratio, 0.15.
3. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that duct systems comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
  - b. Product Data for Prerequisite EA 2: Documentation indicating that duct systems comply with ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
  - c. Leakage Test Report for Prerequisite EA 2: Documentation of work performed for compliance with ASHRAE/IESNA 90.1, Section 6.4.4.2.2 - "Duct Leakage Tests."
  - d. Duct-Cleaning Test Report for Prerequisite EQ 1: Documentation of work performed for compliance with ASHRAE 62.1, Section 7.2.4 - "Ventilation System Start-Up."
  - e. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings:



- a. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
- b. Duct layout indicating sizes and pressure classes.
- c. Elevation of top of ducts.
- d. Dimensions of main duct runs from building grid lines.
- e. Fittings.
- f. Reinforcement and spacing.
- g. Seam and joint construction.
- h. Penetrations through fire-rated and other partitions.
- i. Equipment installation based on equipment being used on Project.
- j. Hangers and supports, including methods for duct and building attachment, seismic restraints, **as directed**, and vibration isolation.
4. Delegated-Design Submittal:
  - a. Duct materials and thicknesses.
  - b. Joint and seam construction and sealing.
  - c. Reinforcement details and spacing.
  - d. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation, **as directed**, for selecting hangers and supports and seismic restraints, **as directed**.
5. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - a. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
  - b. Suspended ceiling components.
  - c. Structural members to which duct will be attached.
  - d. Size and location of initial access modules for acoustical tile.
  - e. Penetrations of smoke barriers and fire-rated construction.
  - f. Items penetrating finished ceiling including the following:
    - 1) Lighting fixtures.
    - 2) Air outlets and inlets.
    - 3) Speakers.
    - 4) Sprinklers.
    - 5) Access panels.
    - 6) Perimeter moldings.
6. Welding certificates.
7. Field quality-control reports.
- E. Quality Assurance
  1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports **OR** AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports, **as directed**.
  2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
  3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."
  4. NFPA Compliance:
    - a. NFPA 90A, "Installation of Air Conditioning and Ventilating Systems."
    - b. NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

## 1.2 PRODUCTS

### A. Fibrous-Glass Ducts And Fittings

1. Fibrous-Glass Duct Materials: Resin-bonded fiberglass, faced on the outside surface with fire-resistive FSK vapor retarder and with a smooth fiberglass mat finish on the air-side surface.
  - a. Duct Board: Factory molded into rectangular boards.
  - b. Round Duct: Factory molded into straight round duct and smooth fittings.
  - c. Temperature Limits: 40 to 250 deg F (5 to 121 deg C) inside ducts; 150 deg F (66 deg C) ambient temperature surrounding ducts.
  - d. Maximum Thermal Conductivity: 0.24 Btu x in./h x sq. ft. x deg F (0.035 W/m x K) at 75 deg F (24 deg C) mean temperature.
  - e. Moisture Absorption: Not exceeding 5 percent by weight at 120 deg F (49 deg C) and 95 percent relative humidity for 96 hours when tested according to ASTM C 1104/C 1104M.
  - f. Permeability: 0.02 perms (1.15 ng/Pa x s x sq. m) maximum when tested according to ASTM E 96/E 96M, Procedure A.
  - g. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
  - h. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C 423, Mounting A.
  - i. Required Markings: EI rating, UL label, and other markings required by UL 181 on each full sheet of duct board.
2. Closure Materials:
  - a. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-P," the manufacturer's name, and a date code.
    - 1) Tape: Aluminum foil-scrim tape imprinted with listing information.
    - 2) Minimum Tape Width: 2-1/2 inches (64 mm); 3 inches (76 mm) for duct board thicker than 1 inch (25 mm).
    - 3) Staples: 1/2-inch (13-mm) outward clinching, 2 inches (51 mm) o.c. in tabs, one tab per joint.
    - 4) Water resistant.
    - 5) Mold and mildew resistant.
  - b. Heat-Activated Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-H," the manufacturer's name, and a date code.
    - 1) Tape: Aluminum foil-scrim tape imprinted with listing information.
    - 2) Minimum Tape Width: 3 inches (76 mm).
    - 3) Heat-Sensitive Imprint: Printed indicator on tape to show proper heating during application has been achieved.
    - 4) Water resistant.
    - 5) Mold and mildew resistant.
  - c. Two-Part Tape Sealing System: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-M," the manufacturer's name, and a date code.
    - 1) Tape: Woven glass fiber impregnated with mineral gypsum.
    - 2) Minimum Tape Width: 3 inches (76 mm).
    - 3) Sealant: Modified styrene acrylic.
    - 4) Water resistant.
    - 5) Mold and mildew resistant.
    - 6) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fabrication:
  - a. Select joints, seams, transitions, elbows, and branch connections and fabricate according to SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 2, "Specifications and Closure," and Chapter 4, "Fittings and Connections" OR NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section II, "Fabrication of Straight Duct Modules," Section III, "Fabrication of Fittings from Modules or Flat Board," and Section IV, "Closure", **as directed**.
  - b. Fabricate 90-degree mitered elbows to include turning vanes.
  - c. Reinforcements: Comply with requirements in SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 5, "Reinforcement" OR NAIMA AH116, "Fibrous Glass



Duct Construction Standards," Section V, "Reinforcement", **as directed**, for channel- and tie-rod reinforcement materials, spacing, and fabrication.

- d. Preformed Round Duct: Comply with NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VII, "Preformed Round Duct."

#### B. Phenolic-Foam Ducts And Fittings

1. Duct Panel: CFC-free phenolic-foam bonded on both sides with factory-applied **0.001-inch- (0.025-mm-)** thick, aluminum foil reinforced with fiberglass scrim.
  - a. Maximum Temperature: **158 deg F (70 deg C)** inside ducts or ambient temperature surrounding ducts.
  - b. Maximum Thermal Conductivity: **0.13 Btu x in./h x sq. ft. x deg F (0.019 W/m x K)** at **75 deg F (24 deg C)** mean temperature.
  - c. Permeability: **0.0002 perms (0.0115 ng/Pa x s x sq. m)** maximum when tested according to ASTM E 96/E 96M, Procedure A.
  - d. Antimicrobial Agent: Compound shall be tested for efficacy by an NRTL, and registered by the EPA for use in HVAC systems.
  - e. Noise-Reduction Coefficient: 0.65 minimum when tested according to ASTM C 423, Mounting A.
  - f. Required Markings: UL label and other markings required by UL 181 on each full sheet of duct panel; UL ratings for closure materials.
2. Closure Materials:
  - a. V-Groove Adhesive: Silicone.
    - 1) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - b. Pressure-Sensitive Tape: Comply with UL 181A; imprinted by the manufacturer with the coding "181A-P," the manufacturer's name, and a date code.
    - 1) Tape: Aluminum foil tape imprinted with listing information.
    - 2) Minimum Tape Width: **3 inches (76 mm)**.
    - 3) Water resistant.
    - 4) Mold and mildew resistant.
  - c. Polymeric Sealing System:
    - 1) Structural Membrane: Woven glass fiber.
    - 2) Minimum Tape Width: **3 inches (76 mm)**.
    - 3) Sealant: Water based.
    - 4) Color: White.
    - 5) Water resistant.
    - 6) Mold and mildew resistant.
    - 7) For indoor applications, use sealant that has a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Fabrication:
  - a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, access doors and panels, and damage repairs according to Knauf Insulation's "Knauf KoolDuct System Design Guide," Section 4, "Duct Construction," and Section 5, "Ductwork System General."
  - b. Fabricate 90-degree mitered elbows to include turning vanes.

#### C. Thermoset FRP Ducts And Fittings

1. Duct and Fittings:
  - a. Thermoset FRP Resin: Manufacture duct with resin that complies with UL 181, Class 1, maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested by an NRTL according to ASTM E 84.
  - b. Inner Liner: FSK liner rated by an NRTL to comply with UL 181, Class 1.
  - c. Round Duct: ASTM D 2996, Type I, Grade 2, Class E, filament-wound duct, minimum **0.125-inch (3.2-mm)** wall thickness, with tapered bell and spigot ends for adhesive joints, or plain ends with couplings.

- d. Round Fittings: Compression or spray-up/contact, molded of same material, pressure class, and joining method as duct.
  - e. Rectangular Fittings: Minimum 0.125-inch- (3.2-mm-) thick flat sheet with fiberglass roving and resin-reinforced joints and seams.
  - f. Double-Wall Insulated Duct: Inner and outer duct complying with requirements for "Round Duct" description above. Polyurethane foam or isocyanurate insulation with maximum thermal conductivity of 0.14 Btu x in./h x sq. ft. x deg F (0.020 W/m x K) at 75 deg F (24 deg C) mean temperature.
  2. Joining Materials: Roving and polyester resin.
    - a. Use fiberglass adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  3. Fabrication:
    - a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."
    - b. Fabricate 90-degree rectangular mitered elbows to include turning vanes, 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
  4. Drains: Formed drain pockets with a minimum of NPS 1 (DN 25) threaded pipe connections.
- D. PVC Ducts And Fittings
1. Duct and Fittings:
    - a. Round Duct: Comply with cell Classification 12454-B in ASTM D 1784, with external loading properties of ASTM D 2412.
    - b. Round Fittings: Socket end molded of same material, pressure class, and joining method as duct.
    - c. Rectangular Fittings: Minimum 0.125-inch- (3.2-mm-) thick flat sheet with heat-formed corners and continuous welded butt joints.
  2. Joining Materials: PVC solvent cement complying with ASTM D 2564.
    - a. Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - b. Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  3. Fabrication:
    - a. Fabricate joints, seams, transitions, reinforcement, elbows, branch connections, and access doors and panels according to SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Chapter 3, "Standards of Construction for PVC Duct Systems."
    - b. Fabricate 90-degree rectangular mitered elbows to include turning vanes, 90-degree round elbows with a minimum of three segments for 12 inches (300 mm) and smaller and a minimum of five segments for 14 inches (350 mm) and larger.
  4. Drains: PVC drain pockets with a minimum of NPS 1 (DN 25) threaded PVC pipe connections.
- E. Hangers And Supports
1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
  2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
  3. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."
  4. Steel Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**, steel with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
  5. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
  6. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.



F. Seismic-Restraint Devices

1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
  - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.
3. Restraint Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**, steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

1.3 EXECUTION

A. Duct Installation

1. Install ducts with fewest possible joints.
2. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.
3. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
4. Install ducts with a clearance of **1 inch (25 mm)**, plus allowance for insulation thickness.
5. Where ducts pass through non-fire-rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges. Overlap openings on four sides by at least **1-1/2 inches (38 mm)**.
6. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
7. Protect duct interiors from the moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines", **as directed**.
8. Install fibrous-glass ducts and fittings to comply with NAIMA AH116, "Fibrous Glass Duct Construction Standards" **OR** SMACNA's "Fibrous Glass Duct Construction Standards", **as directed**.
9. Install foam ducts and fittings to comply with Knauf Insulation's "Knauf KoolDuct System Design Guide."
10. Install thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual."
11. Install PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual."

B. Hanger And Support Installation

1. Install hangers and supports for fibrous-glass ducts and fittings to comply with SMACNA's "Fibrous Glass Duct Construction Standards," Chapter 6, "Hangers and Supports" **OR** NAIMA AH116, "Fibrous Glass Duct Construction Standards," Section VI, "Hangers and Supports", **as directed**.
2. Install hangers and supports for phenolic-foam ducts and fittings to comply with Knauf Insulation's "Knauf KoolDuct System Design Guide," Section 5, "Ductwork System General."



3. Install hangers and supports for thermoset FRP ducts and fittings to comply with SMACNA's "Thermoset FRP Duct Construction Manual," Chapter 7, "Requirements."
  4. Install hangers and supports for PVC ducts and fittings to comply with SMACNA's "Thermoplastic Duct (PVC) Construction Manual," Chapter 3, "Standards of Construction for PVC Duct Systems."
  5. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
    - a. Install concrete inserts before placing concrete.
    - b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
    - c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than **4 inches (100 mm)** thick.
    - d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than **4 inches (100 mm)** thick.
    - e. Do not use powder-actuated concrete fasteners for seismic restraints.
  6. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
- C. Seismic-Restraint-Device Installation
1. Install ducts with hangers and braces designed to support the duct and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR** ASCE/SEI 7, **as directed**.
    - a. Space lateral supports a maximum of **40 feet (12 m)** o.c., and longitudinal supports a maximum of **80 feet (24 m)** o.c.
    - b. Brace a change of direction longer than **12 feet (3.7 m)**.
  2. Select sizes of components so strength will be adequate to carry present and future static and seismic loads within restraint device capacity.
  3. Install cables so they do not bend across edges of adjacent equipment or building structure.
  4. Install cable restraints where ducts are suspended with vibration isolators.
  5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
  6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure to flanges of beams, to upper truss chords of bar joists, or to concrete members.
  7. Drilling for and Setting Anchors:
    - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
    - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
    - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
    - d. Set anchors to manufacturer's recommended torque, using a torque wrench.
    - e. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.
- D. Painting
1. Paint interior of thermoset FRP and PVC ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized-steel primer. Paint materials and application requirements are specified in Division 07.
- E. Field Quality Control
1. Perform tests and inspections.
  2. Leakage Tests:

- a. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
  - b. Test the following systems:
    - 1) Ducts with a Pressure Class Higher Than **3-Inch wg (750 Pa)**: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 25 percent of total installed duct area for each designated pressure class.
    - 2) Supply Ducts with a Pressure Class of **2-Inch wg (500 Pa) OR 3-Inch wg (750 Pa) OR 4-Inch wg (1000 Pa)**, **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
    - 3) Return Ducts with a Pressure Class of **2-Inch wg (500 Pa) OR 3-Inch wg (750 Pa) OR 4-Inch wg (1000 Pa)**, **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
    - 4) Exhaust Ducts with a Pressure Class of **2-Inch wg (500 Pa) OR 3-Inch wg (750 Pa) OR 4-Inch wg (1000 Pa)**, **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
    - 5) Outdoor Air Ducts with a Pressure Class of **2-Inch wg (500 Pa) OR 3-Inch wg (750 Pa) OR 4-Inch wg (1000 Pa)**, **as directed**, or Higher: Test representative duct sections, selected by the Owner from sections installed, **as directed**, totaling no less than 50 **OR** 100, **as directed**, percent of total installed duct area for each designated pressure class.
  - c. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
  - d. Test for leaks before applying external insulation.
  - e. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
  3. Duct System Cleanliness Tests:
    - a. Visually inspect duct system to ensure that no visible contaminants are present.
    - b. Test sections of nonmetal duct system, chosen randomly by the Owner, for cleanliness according to "Vacuum Test" in NADCA ACR, "Assessment, Cleaning and Restoration of HVAC Systems."
      - 1) Acceptable Cleanliness Level: Net weight of debris collected on the filter media shall not exceed 0.75 mg/100 sq. cm.
  4. Duct system will be considered defective if it does not pass tests and inspections.
  5. Prepare test and inspection reports.
- F. Duct Cleaning
1. Clean new **OR** existing **OR** new and existing, **as directed**, duct system(s) before testing, adjusting, and balancing.
  2. Use service openings for entry and inspection.
    - a. Create new openings and install access panels appropriate for duct static-pressure class if required for cleaning access. Provide insulated panels for insulated or lined duct. Patch duct as recommended by duct manufacturer. Comply with Division 23 Section "Air Duct Accessories" for access panels and doors.
    - b. Disconnect and reconnect flexible ducts as needed for cleaning and inspection.
    - c. Remove and reinstall ceiling to gain access during the cleaning process.
  3. Particulate Collection and Odor Control:



- a. When venting vacuuming system inside the building, use HEPA filtration with 99.97 percent collection efficiency for 0.3-micron-size (or larger) particles.
    - b. When venting vacuuming system to outdoors, use filter to collect debris removed from HVAC system, and locate exhaust downwind and away from air intakes and other points of entry into building.
  4. Clean the following components by removing surface contaminants and deposits:
    - a. Air outlets and inlets (registers, grilles, and diffusers).
    - b. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
    - c. Air-handling unit internal surfaces and components including mixing box, coil section, air wash systems, spray eliminators, condensate drain pans, humidifiers and dehumidifiers, filters and filter sections, and condensate collectors and drains.
    - d. Coils and related components.
    - e. Return-air ducts, dampers, actuators, and turning vanes except in ceiling plenums and mechanical equipment rooms.
    - f. Supply-air ducts, dampers, actuators, and turning vanes.
    - g. Dedicated exhaust and ventilation components and makeup air systems.
  5. Mechanical Cleaning Methodology:
    - a. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
    - b. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of ducts or duct accessories.
    - c. Clean fibrous-glass duct with HEPA vacuuming equipment; do not permit duct to get wet. Replace fibrous-glass duct that is damaged, deteriorated, or delaminated or that has friable material, mold, or fungus growth.
    - d. Clean coils and coil drain pans according to NADCA 1992. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.
    - e. Provide drainage and cleanup for wash-down procedures.
    - f. Antimicrobial Agents and Coatings: Apply EPA-registered antimicrobial agents if fungus is present. Apply antimicrobial agents according to manufacturer's written instructions after removal of surface deposits and debris.
- G. Start Up
  1. Air Balance: Comply with requirements in Division 23 Section "Testing, Adjusting, And Balancing For Hvac".
- H. Duct Schedule
  1. Indoor Ducts and Fittings:
    - a. Fibrous-Glass Rectangular Ducts and Fittings:
      - 1) Minimum Flexural Rigidity: EI-475 **OR** 800 **OR** 1400, **as directed**.
      - 2) Minimum Board Thickness: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (51 mm), as directed.**
    - b. Fibrous-Glass Round Ducts and Fittings:
      - 1) Minimum Thickness: **1 inch (25 mm).**
    - c. Phenolic-Foam Rectangular Ducts and Fittings:
      - 1) Minimum Panel Thickness: **7/8 inch (22 mm) OR 1-3/32 inches (28 mm), as directed.**
      - 2) Aluminum Cladding: Minimum **0.025 inch (0.635 mm)** thick.
  2. Outdoor Ducts and Fittings:
    - a. Phenolic-Foam Rectangular Ducts and Fittings:
      - 1) Minimum Panel Thickness: **7/8 inch (22 mm) OR 1-3/32 inches (28 mm), as directed.**
      - 2) Aluminum Cladding: Minimum **0.032 inch (0.813 mm)** thick.

- 3) Polymeric Sealing System: Coat ducts, including gang-nail couplings, grip flanges, and couplings.
  - b. Thermoset FRP Round Ducts and Fittings:
    - 1) Double-Wall Insulated Ducts: Minimum **5/8-inch (15.9-mm)** OR **7/8-inch (22.2-mm)**, **as directed**, insulation thickness.
  - c. PVC Round Ducts and Fittings:
3. Underground Ducts:
- a. Thermoset FRP Round Ducts and Fittings:
    - 1) Insulation Thickness: **1 inch (25 mm)**.
    - 2) Drain: Minimum **NPS 1 (DN 25)** PVC pipe with P-trap to air-gap drain.
  - b. PVC Round Ducts and Fittings:
    - 1) Drain: Minimum **NPS 1 (DN 25)** PVC pipe with P-trap to air-gap drain.

END OF SECTION 23 31 16 13



Task	Specification	Specification Description
23 31 16 13	23 31 13 13	Metal Ducts
23 31 16 16	23 31 13 13	Metal Ducts
23 31 16 16	23 31 16 13	Nonmetal Ducts

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## SECTION 23 33 13 13 - DRAFT CONTROL DEVICES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for draft control devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Draft inducer fans.
  - b. Venturi-draft inducer fans.
  - c. Mechanical-draft vent fans.
  - d. Vent exhaust fans.
  - e. Barometric dampers.
  - f. Vent dampers.
  - g. Combustion-air fans.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and Maintenance Data.
4. Warranty: Warranty specified in this Section.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

#### E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of draft inducer fans, venturi-draft inducer fans, mechanical-draft vent fans, vent exhaust fans, barometric dampers, vent dampers, and/or combustion-air fans that fail in materials or workmanship within two **OR 10, as directed**, years from date of Final Completion.
  - a. Failures include failure of the fan due to corrosion.

### 1.2 PRODUCTS

#### A. Draft Inducer Fans

1. Fan Construction: Galvanized **OR** Aluminized, **as directed**,-steel housing and radial-blade centrifugal fan.
  - a. Fan Motor: Permanent split-capacitor type.
2. Controls:
  - a. Draft proving switch.
  - b. Control kit to cycle fan with gas flow to a single burner.

#### B. Venturi-Draft Inducer Fans

1. Fan Construction: Enameled-steel venturi tube for vents **20 inches (508 mm)** in diameter and smaller, and ASTM A 666, Type 304, stainless-steel venturi tube for vents **22 to 48 inches (559 to 1219 mm)** in diameter. Galvanized **OR** Enameled, **as directed**, -steel fan housing with radial-blade centrifugal wheel.

- a. Fan Motor: Permanent split-capacitor type.
  2. Controls:
    - a. Draft proving switch.
    - b. Control kit to cycle fan with gas flow to a single burner.
- C. Mechanical-Draft Vent Fans
1. Fan Construction: Forward-curved centrifugal fan and scroll fabricated of aluminized **OR** galvanized, **as directed**, steel; direct-drive, ball-bearing motor lubricated with synthetic oil; internal cooling fan; stainless-steel shaft; and integral pressure-sensing switch.
    - a. Fan Motor: Permanent split-capacitor type.
  2. Controls:
    - a. Draft proving switch.
    - b. Control kit to cycle fan with gas flow to single **OR** multiple, **as directed**, burner(s).
  3. Accessories:
    - a. Aluminized **OR** Stainless, **as directed**, -steel, wall-vent hood.
- D. Vent Exhaust Fans
1. General: Centrifugal fan with variable **OR** constant, **as directed**, -speed control mounted at end of sidewall **OR** vertical, **as directed**, vent.
  2. Test Standard: UL 378, for fans exposed to flue gases up to 640 deg F (337 deg C).
  3. Fan Construction: Cast-aluminum **OR** Galvanized-steel **OR** Stainless-steel, **as directed**, housing painted manufacturer's standard color of baked enamel, **as directed**. Galvanized **OR** Stainless, **as directed**, -steel vent. Cast-aluminum **OR** Stainless-steel, **as directed**, wheel. Backward-inclined centrifugal or axial fan wheel statically and dynamically balanced. Provide access to clean the discharge area. Concentric makeup air inlet duct surrounding the vent to allow zero clearance to combustibles, **as directed**.
  4. Motor: Fully enclosed, variable-speed duty, **as directed**, permanent split capacitor, out of the airstream, with prelubricated and sealed ball bearings.
  5. Constant-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure switch permits burner operation via interlock with boiler. Fan proving switch is adjustable between **minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa)**.
  6. Variable-Speed Controls: Boiler interlock relay starts fan when burner control cycles on. Pressure controller, control transformer, and miscellaneous controls for automatic modulation of fan speed to maintain preset negative pressure between **0- and minus 1.0-inch wg (0 and minus 249 Pa)**. Include controller with indicator lights, pressure differential transmitter, chimney pressure sensor probe, and fan proving switch adjustable between **minus 0.07- and minus 0.15-inch wg (minus 17 and minus 37 Pa)**. Include tubing.
- E. Barometric Dampers
1. Damper Construction: High-temperature-enamel-painted steel damper and housing with galvanized-steel breeching connection. Adjustable counterweight with lock. Include knife-edge bearings that do not require lubrication.
- F. Vent Dampers
1. Damper Construction: Stainless-steel damper blade, shaft, and vent pipe with metal, prelubricated bearings.
    - a. Electric motor sized to power damper open and closed in approximately 15 seconds in each direction. Power is off when damper is at rest.
    - b. Comply with ANSI Z21.66.
  2. Controls:
    - a. Control transformer.
    - b. Keyed wiring harness.
    - c. Damper end-switch to prove damper is open.
    - d. Interlock with boiler to permit burner operation when damper is open.
    - e. Hold-open switch for troubleshooting boiler controls.

G. Combustion-Air Fans

1. Fan Construction: Galvanized **OR** Aluminized, **as directed**, -steel housing; steel forward-curved fan and scroll; direct-drive, totally enclosed, fan-cooled motor with ball bearings; stainless-steel shaft; and integral pressure-sensing switch.
  - a. Internal bypass to temper supply-air temperature to room.
2. Controls:
  - a. Fan proving switch to permit burner operation when combustion-air fan is operating.
  - b. Multiple appliance control starts fan with operation of any one of three **OR** four, **as directed**, appliances.
  - c. Modulating combustion-air fan speed to control pressure differential in room with respect to outdoors.
  - d. Manual-reset, high-limit switch stops operation with **160 deg F (71 deg C)** room temperature.
  - e. Optional Controls:
    - 1) Alarm circuit.
    - 2) Excessive negative pressure limit.
    - 3) Interface relay for vent exhaust fan, draft inducer fan, or mechanical-draft vent fan.
    - 4) Galvanized-steel **OR** Aluminum, **as directed**, intake hood.

H. Motors

1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

1.3 EXECUTION

A. Installation

1. Install listed components in a manner complying with the listing.
2. Secure barometric dampers to breechings with hardware compatible with connected materials.
3. Locate barometric and motorized vent dampers as close to draft hood collar as possible.
4. Secure barometric and motorized vent dampers to appliances, breechings, or chimneys with hardware compatible with connected materials.
5. Install draft inducer fans in single-wall vent section that is designed to couple with other vent materials.
6. Secure draft inducer fans to appliances, breechings, or stacks with hardware compatible with connected materials.
7. Install draft inducer fans with clearances for service and maintenance.
8. Install PVC, **as directed**, intake duct that is sized according to manufacturer's written instructions.

B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
  - a. Complete installation and startup checks according to manufacturer's written instructions.
2. Remove and replace malfunctioning components and recheck.

D. Adjusting

1. Set field-adjustable switches and controls as indicated.

E. Demonstration

1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, Owner's maintenance personnel to adjust, operate, and maintain draft control devices.





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END OF SECTION 23 33 13 13

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Task	Specification	Specification Description
23 33 13 13	23 31 13 19	Duct Accessories
23 33 13 16	23 31 13 19	Duct Accessories
23 33 13 33	23 31 13 19	Duct Accessories
23 33 13 43	23 31 13 19	Duct Accessories
23 33 23 00	23 31 13 19	Duct Accessories
23 33 33 00	23 31 13 19	Duct Accessories
23 33 43 00	23 31 13 19	Duct Accessories
23 33 46 00	23 31 13 13	Metal Ducts
23 33 46 00	23 31 13 19	Duct Accessories
23 33 53 00	01 22 16 00	No Specification Required
23 33 53 00	23 31 13 13	Metal Ducts
23 33 53 00	23 31 13 13a	HVAC Casings
23 33 56 00	23 31 13 13	Metal Ducts
23 33 56 00	23 31 13 19	Duct Accessories
23 33 59 00	23 31 13 19	Duct Accessories



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## SECTION 23 34 13 00 - AXIAL FANS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for axial fans. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Tubeaxial fans.
  - b. Vaneaxial fans.
  - c. Mixed-flow fans.

#### C. Performance Requirements

1. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
2. Operating Limits: Classify according to AMCA 99.

#### D. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:
  - a. Certified fan performance curves with system operating conditions indicated.
  - b. Certified fan sound-power ratings.
  - c. Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - d. Material thickness and finishes, including color charts.
  - e. Dampers, including housings, linkages, and operators.
  - f. Fan speed controllers.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - a. Wiring Diagrams: Power, signal, and control wiring.
  - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
  - c. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
3. Coordination Drawings: Show fan room layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate and certify field measurements.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For axial fans to include in emergency, operation, and maintenance manuals.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
3. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

#### F. Delivery, Storage, And Handling



1. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
2. Disassemble and reassemble units, as required for moving to final locations, according to manufacturer's written instructions.
3. Lift and support units with manufacturer's designated lifting or supporting points.

G. Coordination

1. Coordinate size and location of structural-steel support members.
2. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 31..
3. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories".

## 1.2 PRODUCTS

A. Tubeaxial Fans

1. Description: Fan wheel and housing, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
2. Housings: Steel **OR** Galvanized steel **OR** Aluminum **OR** Fiberglass-reinforced plastic **OR** Stainless steel, **as directed**, with flanged inlet and outlet connections.
3. Wheel Assemblies: Cast or extruded aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key **OR** Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft **OR** Cast aluminum, machined and fitted to shaft, **as directed**.
4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
  - a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
  - b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
  - c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
  - d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
  - f. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
  - g. Motor Mount: Adjustable base.
  - h. Shaft Bearings: Radial, self-aligning ball or roller bearings.
    - 1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.  
**OR**  
Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
    - 2) Extend lubrication lines to outside of casing and terminate with grease fittings.
5. Accessories:
  - a. Companion Flanges: Rolled flanges of same material as housing.
  - b. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
  - c. Propeller Access Section Door: Short duct section bolted to fan inlet **OR** outlet **OR** inlet and outlet, **as directed**, allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
  - d. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
  - e. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed**, clips welded to fan housing, of same material as housing.
  - f. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
  - g. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.

- h. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork, of same material as housing.
- i. Backdraft Dampers: Butterfly style, for bolting to the discharge of fan or outlet cone, of same material as housing.
- j. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (149 deg C).
- k. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
- l. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
- m. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing **OR** aluminum, **as directed**.
- n. Inlet Cones: Round-to-round transition of same material as housing.
- o. Outlet Cones: Round-to-round transition of same material as housing.
- p. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
- 6. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
  - b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing, **as directed**.
- 7. Factory Finishes:
  - a. Sheet Metal Parts: Prime coat before final assembly.
  - b. Exterior Surfaces: Baked-enamel finish coat after assembly.
  - c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
    - 1) Apply to finished housings.
    - 2) Apply to fan wheels.
- B. Vaneaxial Fans
  - 1. Description: Fan wheel and housing, straightening vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
    - a. Variable-Pitch Fans: Internally mounted pneumatic **OR** electric **OR** electronic, **as directed**, actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.
  - 2. Housings: Steel **OR** Galvanized steel **OR** Aluminum **OR** Fiberglass-reinforced plastic **OR** Stainless steel, **as directed**.
    - a. Inlet and Outlet Connections: Flanges.
    - b. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
  - 3. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key **OR** Fiberglass-reinforced plastic cured under pressure with airfoil-shaped blades keyed to stainless steel shaft **OR** Cast-aluminum hub assembly, machined and fitted with threaded bearing wells to receive blade-bearing assemblies with replaceable, cast-aluminum blades; factory mounted and balanced, **as directed**.
  - 4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
    - a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
    - b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
    - c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
    - d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
    - e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.

- f. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
- g. Motor Mount: Adjustable base.
- h. Shaft Bearings: Radial, self-aligning ball or roller bearings.
  - 1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.
  - OR**
  - Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
  - 2) Extend lubrication lines to outside of casing and terminate with grease fittings.
- 5. Accessories:
  - a. Companion Flanges: Rolled flanges of same material as housing.
  - b. Inspection Door: Bolted door allowing limited access to internal parts of fan, of same material as housing.
  - c. Propeller Access Section Door: Short duct section bolted to fan inlet **OR** outlet **OR** inlet and outlet, **as directed**, allowing access to internal parts of fan for inspection and cleaning, of same material as housing.
  - d. Swingout Construction: Assembly allowing entire fan section to swing out from duct for cleaning and servicing, of same material as housing.
  - e. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed**, clips welded to fan housing, of same material as housing.
  - f. Horizontal Support: Pair of supports bolted to fan housing, of same material as housing.
  - g. Vertical Support: Short duct section with welded brackets bolted to fan housing, of same material as housing.
  - h. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
  - i. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
  - j. Stall Alarm Probe: Sensing probe capable of detecting fan operation in stall and signaling control devices. Control devices and sequence of operation are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
  - k. Flow Measurement Port: Pressure measurement taps installed in the inlet of fan to detect and signal airflow readings to temperature-control systems. Control devices and sequence of operation are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
  - l. Shaft Seal: Elastomeric seal and Teflon wear plate, suitable for up to 300 deg F (148 deg C).
  - m. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
  - n. Inlet Vanes: Adjustable; with peripheral control linkage operated from outside of airstream, bronze sleeve bearings on each end of vane support, and provision for manual or automatic operation of same material as housing.
  - o. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
  - p. Inlet Cones: Round-to-round transition of same material as housing.
  - q. Outlet Cones: Round-to-round transition of same material as housing.
  - r. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
- 6. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
  - b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing, **as directed**.
- 7. Factory Finishes:
  - a. Sheet Metal Parts: Prime coat before final assembly.
  - b. Exterior Surfaces: Baked-enamel finish coat after assembly.



- c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
    - 1) Apply to finished housings.
    - 2) Apply to fan wheels.
- C. Mixed-Flow Fans
1. Description: Fan wheel and housing, straightening vane section, **as directed**, factory-mounted motor with belt drive, and accessories.
  2. Housings: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**.
    - a. Inlet and Outlet Connections: Outer mounting frame and companion flanges.
    - b. Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
    - c. Mixed-Flow Outlet Connection: One **OR** Two, **as directed**, flanged discharge(s) perpendicular to fan inlet.
  3. Wheel Assemblies: Cast aluminum with airfoil-shaped blades mounted on cast-iron wheel plate keyed to shaft with solid-steel key.
  4. Drives: Factory mounted, with final alignment and belt adjustment made after installation.
    - a. Service Factor Based on Fan Motor Size: 1.2 **OR** 1.3 **OR** 1.4 **OR** 1.5, **as directed**.
    - b. Fan Shaft: Turned, ground, and polished steel designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
    - c. Fan Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
    - d. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
    - e. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
    - f. Motor Mount: Adjustable base.
    - g. Shaft Bearings: Radial, self-aligning ball or roller bearings.
      - 1) Ball-Bearing Rating Life: ABMA 9, L10 of 100,000 hours.  
**OR**  
Roller-Bearing Rating Life: ABMA 11, L10 of 100,000 hours.
      - 2) Extend lubrication lines to outside of casing and terminate with grease fittings.
  5. Accessories:
    - a. Mounting Clips: Horizontal ceiling **OR** Vertical mounting, **as directed**, clips welded to fan housing, of same material as housing.
    - b. Inlet and Outlet Screens: Wire-mesh screen on fans not connected to ductwork of same material as housing.
    - c. Backdraft Dampers: Butterfly style, for mounting with flexible connection to the discharge of fan or direct mounted to the discharge diffuser section of same material as housing.
    - d. Motor Cover: Cover with side vents to dissipate motor heat, of same material as housing.
    - e. Inlet Bell: Curved inlet for when fan is not attached to duct, of same material as housing.
    - f. Inlet Cones: Round-to-round transition of same material as housing.
    - g. Outlet Cones: Round-to-round transition of same material as housing.
    - h. Stack Cap: Vertical discharge assembly with backdraft dampers, of same material as housing.
  6. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - a. Enclosure Type: Totally enclosed, fan cooled **OR** Totally enclosed, nonventilated, **as directed**.
    - b. Direct-Driven Units: Encase motor in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.
  7. Factory Finishes:
    - a. Sheet Metal Parts: Prime coat before final assembly.
    - b. Exterior Surfaces: Baked-enamel finish coat after assembly.



- c. Coatings: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Color-match enamel **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.

- 1) Apply to finished housings.
- 2) Apply to fan wheels.

D. Source Quality Control

- 1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- 2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

### 1.3 EXECUTION

A. Installation

- 1. Install axial fans level and plumb.
- 2. Support floor-mounting units using spring isolators **OR** restrained spring isolators, **as directed**, having a static deflection of **1 inch (25 mm)**. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
- 3. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
- 4. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
- 5. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, having a static deflection of **1 inch (25 mm)**. Vibration-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- 6. Install units with clearances for service and maintenance.
- 7. Label fans according to requirements specified in Division 23 Section "Identification For Hvac Piping And Equipment".

B. Connections

- 1. Duct installation and connection requirements are specified in other Division 21. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories".
- 2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
- 3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

- 1. Perform the following field tests and inspections and prepare test reports:
  - a. Verify that shipping, blocking, and bracing are removed.
  - b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - c. Verify that cleaning and adjusting are complete.

- d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  - e. Adjust belt tension.
  - f. Adjust damper linkages for proper damper operation.
  - g. Verify lubrication for bearings and other moving parts.
  - h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  - i. Disable automatic temperature-control operators, energize motor and confirm proper motor rotation and unit operation, adjust fan to indicated rpm, and measure and record motor voltage and amperage.
  - j. Shut unit down and reconnect automatic temperature-control operators.
  - k. Remove and replace malfunctioning units and retest as specified above.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

D. Adjusting

1. Adjust damper linkages for proper damper operation.
2. Adjust belt tension.
3. Lubricate bearings.

END OF SECTION 23 34 13 00

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## SECTION 23 34 16 00 - CENTRIFUGAL FANS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for centrifugal fans. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Airfoil centrifugal fans.
  - b. Backward-inclined centrifugal fans.
  - c. Forward-curved centrifugal fans.
  - d. Plenum fans.
  - e. Plug fans.

#### C. Performance Requirements

1. Project Altitude: Base fan performance ratings on actual Project site elevations above sea level.
2. Operating Limits: Classify according to AMCA 99.

#### D. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Field quality-control test reports.
4. Operation and maintenance data.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
3. NEMA Compliance: Motors and electrical accessories shall comply with NEMA 1.

#### F. Delivery, Storage, And Handling

1. Deliver fans as factory-assembled units, to the extent allowable by shipping limitations, with protective crating and covering.
2. Disassemble and reassemble units, as required for moving to the final location, according to manufacturer's written instructions.
3. Lift and support units with manufacturer's designated lifting or supporting points.

### 1.2 PRODUCTS

#### A. Airfoil Centrifugal Fans

1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.



2. Housings: Formed panels to make curved-scroll housings with shaped cutoff, with doors or panels to allow access to internal parts and components.
  - a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
  - b. Horizontally split, bolted-flange housing.
  - c. Spun inlet cone with flange.
  - d. Outlet flange.
3. Airfoil Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating, **as directed**.
4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
  - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
  - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
  - a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
  - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
  - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
  - f. Motor Mount: Adjustable for belt tensioning.
9. Accessories:
  - a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
  - b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed**, gasketed door allowing access to fan scroll, of same material as housing.
  - c. Scroll Drain Connection: **NPS 1 (DN 25)** steel pipe coupling welded to low point of fan scroll.
  - d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
  - e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
  - f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed**, blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.

- g. Inlet Screens: Grid screen of same material as housing.
- h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
- i. Spark-Resistant Construction: AMCA 99.
- j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
- k. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
- 10. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Enclosure Type: Totally enclosed, fan cooled.
- B. Backward-Inclined Centrifugal Fans
  - 1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and support structure.
  - 2. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.
    - a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
    - b. Spun inlet cone with flange.
    - c. Outlet flange.
  - 3. Backward-Inclined Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate, **as directed**, and fastened to shaft with set screws.
  - 4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
    - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
    - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
  - 5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
    - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
    - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - 6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
    - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
    - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - 7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
    - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
    - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - 8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
    - a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**].
    - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
    - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
    - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
    - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
    - f. Motor Mount: Adjustable for belt tensioning.
  - 9. Accessories:



- a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
- b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed**, gasketed door allowing access to fan scroll, of same material as housing.
- c. Scroll Drain Connection: **NPS 1 (DN 25)** steel pipe coupling welded to low point of fan scroll.
- d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
- e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
- f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed**, blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
- g. Inlet Screens: Grid screen of same material as housing.
- h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
- i. Spark-Resistant Construction: AMCA 99.
- j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
- k. Weather Cover: Enameled-steel sheet with ventilation slots, bolted to housing.
- 10. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Enclosure Type: Totally enclosed, fan cooled.

C. Forward-Curved Centrifugal Fans

- 1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
- 2. Housings: Formed panels to make curved-scroll housings with shaped cutoff; with doors or panels to allow access to internal parts and components.
  - a. Panel Bracing: Steel angle- or channel-iron member supports for mounting and supporting fan scroll, wheel, motor, and accessories.
  - b. Horizontally split, bolted-flange housing.
  - c. Spun inlet cone with flange.
  - d. Outlet flange.
- 3. Forward-Curved Wheels: Black-enameled or galvanized steel construction with inlet flange, backplate, shallow blades with inlet and tip curved forward in direction of airflow, mechanically secured to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.
- 4. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
  - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
  - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- 5. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
- 6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
- 7. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.

8. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
  - a. Service Factor Based on Fan Motor Size: 1.5.
  - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
  - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
  - f. Motor Mount: Adjustable for belt tensioning.
9. Accessories:
  - a. Scroll Access Doors: Shaped to conform to scroll, with quick-opening latches and gaskets.
  - b. Cleanout Door: Bolted **OR** Quick-opening, latch-type, **as directed**, gasketed door allowing access to fan scroll, of same material as housing.
  - c. Scroll Drain Connection: **NPS 1 (DN 25)** steel pipe coupling welded to low point of fan scroll.
  - d. Companion Flanges: Rolled flanges for duct connections of same material as housing.
  - e. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
  - f. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed**, blades constructed of two plates formed around and to shaft, channel frame, and sealed ball bearings; with blades linked outside of airstream to single control lever of same material as housing.
  - g. Inlet Screens: Grid screen of same material as housing.
  - h. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
  - i. Spark-Resistant Construction: AMCA 99.
  - j. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
  - k. Weather Cover: Enamelled-steel sheet with ventilation slots, bolted to housing.
10. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Enclosure Type: Totally enclosed, fan cooled.

#### D. Plenum Fans

1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
2. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating.
3. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
  - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
  - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
5. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.



- a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.
  - a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
  - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
  - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
  - f. Motor Mount: Adjustable for belt tensioning.
8. Accessories:
  - a. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
  - b. Spark-Resistant Construction: AMCA 99.
  - c. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
9. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Enclosure Type: Totally enclosed, fan cooled.

#### E. Plug Fans

1. Description: Factory-fabricated, -assembled, -tested, and -finished, belt-driven centrifugal fans consisting of wheel, fan shaft, bearings, motor and disconnect switch, **as directed**, drive assembly, and support structure.
2. Airfoil Wheels: Single-width-single-inlet construction with smooth-curved inlet flange; heavy backplate; hollow die-formed, airfoil-shaped blades continuously welded at tip flange and backplate; and cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws; and special coating, **as directed**.
3. Shafts: Statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
  - a. Turned, ground, and polished hot-rolled steel with keyway. Ship with protective coating of lubricating oil.
  - b. Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
4. Prelubricated and Sealed Shaft Bearings: Self-aligning, pillow-block-type ball bearings.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
5. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, tapered roller bearings with double-locking collars and two-piece, cast-iron housing.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
6. Grease-Lubricated Shaft Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing.
  - a. Ball-Bearing Rating Life: ABMA 9, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
  - b. Roller-Bearing Rating Life: ABMA 11, L10 at 50,000 hours **OR** 120,000 hours, **as directed**.
7. Belt Drives: Factory mounted, with final alignment and belt adjustment made after installation.

- a. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
  - b. Fan Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  - c. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
  - e. Belt Guards: Fabricate to comply with OSHA and SMACNA requirements of diamond-mesh wire screen welded to steel angle frame or equivalent, prime coated. Secure to fan or fan supports without short circuiting vibration isolation. Include provisions for adjustment of belt tension, lubrication, and use of tachometer with guard in place.
  - f. Motor Mount: Adjustable for belt tensioning.
8. Accessories:
- a. Shaft Cooler: Metal disk between bearings and fan wheel, designed to dissipate heat from shaft.
  - b. Spark-Resistant Construction: AMCA 99.
  - c. Shaft Seals: Airtight seals installed around shaft on drive side of single-width fans.
9. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Enclosure Type: Totally enclosed, fan cooled.

F. Source Quality Control

1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

### 1.3 EXECUTION

A. Installation

1. Install centrifugal fans level and plumb.
2. Support floor-mounting units using spring isolators **OR** restrained spring isolators, **as directed**, having a static deflection of 1 inch (25 mm). Vibration- and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
3. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by authorities having jurisdiction. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
5. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, having a static deflection of 1 inch (25 mm). Vibration-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install units with clearances for service and maintenance.
7. Label fans according to requirements specified in Division 23 Section "Identification For Hvac Piping And Equipment".

B. Connections

1. Duct installation and connection requirements are specified in other Division 21. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with

flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories".

2. Install ducts adjacent to fans to allow service and maintenance.
3. Install line-sized piping from scroll drain connection, with trap with seal equal to 1.5 times specified static pressure, to nearest floor drain.
4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
5. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
  - a. Verify that shipping, blocking, and bracing are removed.
  - b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - c. Verify that cleaning and adjusting are complete.
  - d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  - e. Adjust belt tension.
  - f. Adjust damper linkages for proper damper operation.
  - g. Verify lubrication for bearings and other moving parts.
  - h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  - i. Refer to Division 23 Section "Testing, Adjusting, And Balancing For Hvac" for testing, adjusting, and balancing procedures.
  - j. Remove and replace malfunctioning units and retest as specified above.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 34 16 00

## SECTION 23 34 16 00a - POWER VENTILATORS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for power ventilators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Utility set fans.
  - b. Centrifugal roof ventilators.
  - c. Axial roof ventilators.
  - d. Upblast propeller roof exhaust fans.
  - e. Centrifugal wall ventilators.
  - f. Ceiling-mounting ventilators.
  - g. In-line centrifugal fans.
  - h. Propeller fans.

#### C. Performance Requirements

1. Project Altitude: Base fan-performance ratings on actual Project site elevations **OR** sea level, **as directed**.
2. Operating Limits: Classify according to AMCA 99.

#### D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include the following:
  - a. Certified fan performance curves with system operating conditions indicated.
  - b. Certified fan sound-power ratings.
  - c. Motor ratings and electrical characteristics, plus motor and electrical accessories.
  - d. Material thickness and finishes, including color charts.
  - e. Dampers, including housings, linkages, and operators.
  - f. Roof curbs.
  - g. Fan speed controllers.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For unit hangars and supports indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
  - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
4. Field quality-control reports.
  - a. Operation and Maintenance Data: For power ventilators to include in emergency, operation, and maintenance manuals.

#### E. Quality Assurance



1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended use.
2. AMCA Compliance: Fans shall have AMCA-Certified performance ratings and shall bear the AMCA-Certified Ratings Seal.
3. UL Standard: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

## 1.2 PRODUCTS

### A. Utility Set Fans

1. Description: Direct **OR** Belt, **as directed**, driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
2. Housing: Fabricated of galvanized, **as directed**, steel with side sheets fastened with a deep lock seam or welded to scroll sheets.
  - a. Housing Discharge Arrangement: Adjustable to eight standard positions.
3. Fan Wheels: Single-width, single inlet; welded to cast-iron or cast-steel hub and spun-steel inlet cone, with hub keyed to shaft.
  - a. Blade Materials: Steel **OR** Aluminum, **as directed**.
  - b. Blade Type: Backward inclined **OR** Forward curved **OR** Airfoil, **as directed**.
  - c. Spark-Resistant Construction: AMCA 99, Type A **OR** B **OR** C, **as directed**.
4. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
5. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings with ABMA 9, L<sub>50</sub> of 200,000 hours **OR** L<sub>10</sub> of 80,000 hours, **as directed**.
6. Belt Drives:
  - a. Factory mounted, with final alignment and belt adjustment made after installation.
  - b. Service Factor Based on Fan Motor Size: 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**.
  - c. Motor Pulleys: Adjustable pitch for use with motors through 5, **as directed**, hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - d. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
  - e. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
7. Accessories:
  - a. Inlet and Outlet: Flanged.
  - b. Companion Flanges: Rolled flanges for duct connections of same material as housing.
  - c. Backdraft Dampers: Gravity actuated with counterweight and interlocking aluminum blades with felt edges in steel frame installed on fan discharge.
  - d. Access Door: Gasketed door in scroll with latch-type handles.
  - e. Scroll Dampers: Single-blade damper installed at fan scroll top with adjustable linkage.
  - f. Inlet Screens: Removable wire mesh.
  - g. Drain Connections: **NPS 3/4 (DN 20)** threaded coupling drain connection installed at lowest point of housing.
  - h. Weather Hoods: Weather resistant with stamped vents over motor and drive compartment.
  - i. Discharge Dampers: Assembly with parallel **OR** opposed, **as directed**, blades constructed of two plates formed around and to shaft, channel frame, sealed ball bearings, with blades linked outside of airstream to single control lever of same material as housing.
  - j. Variable Inlet Vanes: With blades supported at both ends with two permanently lubricated bearings of same material as housing. Variable mechanism terminating in single control lever with control shaft for double-width fans.
  - k. Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.

### B. Centrifugal Roof Ventilators

1. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.



2. Housing: Removable, spun-aluminum, dome top and outlet baffle **OR** extruded-aluminum, rectangular top **OR** galvanized steel, mushroom-domed top, **as directed**; square, one-piece, aluminum base with venturi inlet cone.
    - a. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains and grease collector, **as directed**.
    - b. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
  3. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
  4. Belt-Driven Drive:
    - a. Resiliently mounted to housing.
    - b. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - c. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - d. Pulleys: Cast-iron, adjustable-pitch motor pulley.
    - e. Fan and motor isolated from exhaust airstream.
  5. Accessories:
    - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
    - b. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside **OR** outside, **as directed**, fan housing, factory wired through an internal aluminum conduit.
    - c. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
    - d. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
    - e. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
  6. Roof Curbs: Galvanized steel; mitered and welded corners; 1-1/2-inch- (40-mm-) thick, rigid, fiberglass insulation adhered to inside walls; and 1-1/2-inch (40-mm) wood nailer. Size as required to suit roof opening and fan base.
    - a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.
    - b. Overall Height: 8 inches (200 mm) **OR** 9-1/2 inches (240 mm) **OR** 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
    - c. Sound Curb: Curb with sound-absorbing insulation matrix.
    - d. Pitch Mounting: Manufacture curb for roof slope.
    - e. Metal Liner: Galvanized steel.
    - f. Burglar Bars: 1/2-inch- (13-mm-) **OR** 5/8-inch- (16-mm-) **OR** 3/4-inch- (19-mm-), **as directed**, thick steel bars welded in place to form 6-inch (150-mm) squares.
    - g. Mounting Pedestal: Galvanized steel with removable access panel.
    - h. Vented Curb: Unlined with louvered vents in vertical sides.
- C. Axial Roof Ventilators
1. Description: Direct- or belt-driven axial fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
  2. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; square, one-piece, hinged, aluminum base.
    - a. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
  3. Fan Wheel: Aluminum **OR** Steel, **as directed**, hub and blades.
  4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
    - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
  5. Accessories:
    - a. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside **OR** outside, **as directed**, fan housing, factory wired through an internal aluminum conduit.
    - b. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.



- c. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
  - d. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- 6. Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch- (40-mm-)** thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch (40-mm)** wood nailer. Size as required to suit roof opening and fan base.
  - a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.
  - b. Overall Height: **8 inches (200 mm) OR 9-1/2 inches (240 mm) OR 12 inches (300 mm) OR 16 inches (400 mm) OR 18 inches (450 mm), as directed.**
  - c. Sound Curb: Curb with sound-absorbing insulation matrix.
  - d. Pitch Mounting: Manufacture curb for roof slope.
  - e. Metal Liner: Galvanized steel.
  - f. Burglar Bars: **1/2-inch- (13-mm-) OR 5/8-inch- (16-mm-) OR 3/4-inch- (19-mm-), as directed,** thick steel bars welded in place to form **6-inch (150-mm)** squares.
  - g. Mounting Pedestal: Galvanized steel with removable access panel.
- D. Upblast Propeller Roof Exhaust Fans
  - 1. Description: Direct- or belt-driven propeller fans consisting of housing, wheel, butterfly-type discharge damper, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
  - 2. Wind Band, Fan Housing, and Base: Reinforced and braced galvanized steel **OR** aluminum, **as directed**, containing galvanized-steel **OR** aluminum, **as directed**, butterfly dampers and rain trough, motor and drive assembly, and fan wheel.
    - a. Damper Rods: Steel with bronze **OR** nylon, **as directed**, bearings.
    - b. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
  - 3. Fan Wheel: Replaceable, cast **OR** extruded, **as directed**, -aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
  - 4. Belt-Driven Drive Assembly: Resiliently mounted to housing; weatherproof housing of same material as fan housing with the following features:
    - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - b. Shaft Bearings: Prelubricated and sealed, self-aligning, pillow-block-type ball bearings.
    - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
    - d. Motor Mount: On outside of fan cabinet, adjustable base for belt tensioning.
  - 5. Roof Curbs: Galvanized steel; mitered and welded corners; **1-1/2-inch- (40-mm-)** thick, rigid, fiberglass insulation adhered to inside walls; and **1-1/2-inch (40-mm)** wood nailer. Size as required to suit roof opening and fan base.
    - a. Configuration: Self-flashing without a cant strip, with mounting flange **OR** Built-in cant and mounting flange **OR** Built-in raised cant and mounting flange, **as directed**.
    - b. Overall Height: **8 inches (200 mm) OR 9-1/2 inches (240 mm) OR 12 inches (300 mm) OR 16 inches (400 mm) OR 18 inches (450 mm), as directed.**
    - c. Sound Curb: Curb with sound-absorbing insulation matrix.
    - d. Pitch Mounting: Manufacture curb for roof slope.
    - e. Metal Liner: Galvanized steel.
    - f. Burglar Bars: **1/2-inch- (13-mm-) OR 5/8-inch- (16-mm-) OR 3/4-inch- (19-mm-), as directed,** thick steel bars welded in place to form **6-inch (150-mm)** squares.
    - g. Mounting Pedestal: Galvanized steel with removable access panel.
- E. Centrifugal Wall Ventilators
  - 1. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.
  - 2. Housing: Heavy-gage, removable, spun-aluminum, dome top and outlet baffle; venturi inlet cone.
  - 3. Fan Wheel: Aluminum hub and wheel with backward-inclined blades.

4. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
    - a. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - b. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - c. Pulleys: Cast-iron, adjustable-pitch motor pulley.
    - d. Fan and motor isolated from exhaust airstream.
  5. Accessories:
    - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
    - b. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through internal aluminum conduit.
    - c. Bird Screens: Removable, 1/2-inch (13-mm) mesh, aluminum or brass wire.
    - d. Wall Grille: Ring type for flush mounting.
    - e. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in wall sleeve; factory set to close when fan stops.
    - f. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.
- F. Ceiling-Mounting Ventilators
1. Description: Centrifugal fans designed for installing in ceiling or wall or for concealed in-line applications.
  2. Housing: Steel, lined with acoustical insulation.
  3. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
  4. Grille: Plastic **OR** Stainless steel **OR** Aluminum **OR** Painted aluminum, **as directed**, louvered grille with flange on intake and thumbscrew attachment to fan housing.
  5. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
  6. Accessories:
    - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
    - b. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
    - c. Time-Delay Switch: Assembly with single-pole rocker switch, timer, and cover plate.
    - d. Motion Sensor: Motion detector with adjustable shutoff timer.
    - e. Ceiling Radiation Damper: Fire-rated assembly with ceramic blanket, stainless-steel springs, and fusible link.
    - f. Filter: Washable aluminum to fit between fan and grille.
    - g. Isolation: Rubber-in-shear vibration isolators.
    - h. Manufacturer's standard roof jack or wall cap, and transition fittings.
- G. In-Line Centrifugal Fans
1. Description: In-line, direct **OR** belt, **as directed**, driven centrifugal fans consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
  2. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
  3. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing; with wheel, inlet cone, and motor on swing-out service door, **as directed**.
  4. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
  5. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
  6. Accessories:
    - a. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
    - b. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
    - c. Companion Flanges: For inlet and outlet duct connections.



- d. Fan Guards: **1/2- by 1-inch (13- by 25-mm)** mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
- e. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.

#### H. Propeller Fans

1. Description: Direct- or belt-driven propeller fans consisting of fan blades, hub, housing, orifice ring, motor, drive assembly, and accessories.
2. Housing: Galvanized-steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
3. Steel Fan Wheels: Formed-steel blades riveted to heavy-gage steel spider bolted to cast-iron hub.
4. Fan Wheel: Replaceable, cast **OR** extruded, **as directed**, -aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
5. Belt-Driven Drive Assembly: Resiliently mounted to housing, statically and dynamically balanced and selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
  - a. Service Factor Based on Fan Motor Size: 1.4.
  - b. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
  - c. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - 1) Ball-Bearing Rating Life: ABMA 9,  $L_{10}$  of 100,000 hours.
  - d. Pulleys: Cast iron with split, tapered bushing; dynamically balanced at factory.
  - e. Motor Pulleys: Adjustable pitch for use with motors through 5 hp; fixed pitch for use with larger motors. Select pulley so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - f. Belts: Oil resistant, nonsparking, and nonstatic; matched sets for multiple belt drives.
  - g. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.
6. Accessories:
  - a. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
  - b. Motor-Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
  - c. Wall Sleeve: Galvanized steel to match fan and accessory size.
  - d. Weathershield Hood: Galvanized steel to match fan and accessory size.
  - e. Weathershield Front Guard: Galvanized steel with expanded metal screen.
  - f. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent.
  - g. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

#### I. Motors

1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
2. Enclosure Type: Open dripproof **OR** Totally enclosed, fan cooled, **as directed**.

#### J. Source Quality Control

1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

### 1.3 EXECUTION

#### A. Installation

1. Install power ventilators level and plumb.
2. Support units using elastomeric mounts **OR** restrained elastomeric mounts **OR** spring isolators **OR** restrained spring isolators, **as directed**, having a static deflection of **1 inch (25 mm)**. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Secure vibration and seismic controls to concrete bases using anchor bolts cast in concrete base.
3. For projects not in seismic areas, install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
4. For projects in seismic areas, install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-place Concrete".
5. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
6. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
7. Support suspended units from structure using threaded steel rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, having a static deflection of **1 inch (25 mm)**. Vibration-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
8. Install units with clearances for service and maintenance.
9. Label units according to requirements specified in Division 23 Section "Identification For Hvac Piping And Equipment".
10. Duct installation and connection requirements are specified in other Division 21. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Air Duct Accessories".
11. Install ducts adjacent to power ventilators to allow service and maintenance.
12. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
13. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### B. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
  - a. Verify that shipping, blocking, and bracing are removed.
  - b. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
  - c. Verify that cleaning and adjusting are complete.
  - d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
  - e. Adjust belt tension.
  - f. Adjust damper linkages for proper damper operation.
  - g. Verify lubrication for bearings and other moving parts.
  - h. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
  - i. Disable automatic temperature-control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
  - j. Shut unit down and reconnect automatic temperature-control operators.
  - k. Remove and replace malfunctioning units and retest as specified above.



2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 34 16 00a

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Task	Specification	Specification Description
23 34 16 00	01 22 16 00	No Specification Required
23 34 23 00	23 34 16 00a	Power Ventilators

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## SECTION 23 34 33 00 - AIR CURTAINS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for air curtains. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes air curtains with hot-water heat, steam heat, electric heat, and gas-fired heater.

#### C. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories for each unit indicated.
2. Shop Drawings: For air curtains. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: Power, signal, and control wiring.
3. Delegated-Design Submittal: For air curtains indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Detail fabrication and assembly of air-curtain mounting assemblies.
  - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints.
4. Operation and maintenance data: For air curtains to include in maintenance manuals.
5. Warranties: Sample of special warranties.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified and marked for intended location and application.
2. Comply with AMCA 220, "Laboratory Methods of Testing Air Curtains for Aerodynamic Performance Ratings," for airflow, outlet velocity, and power consumption.
3. Comply with ARI 410, "Forced-Circulation Air-Cooling and Air-Heating Coils," for components, construction, and rating.
  - a. Certify coils according to ARI 410.
4. Comply with NSF 37, "Air Curtains for Entraceways in Food and Food Service Establishments."

#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air curtains that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period (Nonheating Units): 24 months.
  - b. Warranty Period (Water or Steam Heating Units): 18 **OR** 24 months, **as directed**.
  - c. Warranty Period (Gas Heating Units): 18 **OR** 24 months, **as directed**.

### 1.2 PRODUCTS

#### A. Air-Curtain Unit

1. Housing:

- a. Materials: Galvanized steel with electrostatically applied epoxy enamel finish over powdered mirror
- b. Materials: One-piece, molded, high-impact, white polymer material
- c. Materials: Heavy-gage, electroplated-zinc steel with welded construction and polyester-coated finish.
- d. Materials: Heavy-gage, aluminum construction.
  - 1) Anodized Finish: Match finish and color of adjacent architectural metals. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  - 2) Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
    - a) Class II, Clear Anodic Finish: AA-M12C22A31 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, clear coating 0.010 mm or thicker) complying with AAMA 611.
    - b) Class II, Color Anodic Finish: AA-M12C22A32/A34 (Mechanical Finish: Nonspecular as fabricated; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class II, integrally colored or electrolytically deposited color coating 0.010 mm or thicker).
- e. Materials: Stainless steel.
- f. Discharge Nozzle: Integral part of the housing, containing fixed air-directional vanes.
- g. Discharge Nozzle: Integral part of the housing, containing adjustable air-directional vanes with 40 **OR** 20 **OR** 15-degree sweep front to back, **as directed**.
- h. Discharge Nozzle: Integral part of the housing, containing air-directional vanes adjustable in 5-degree increments through a 45-degree sweep front to back.
2. Mounting Brackets: Steel, for wall **OR** ceiling mounting, **as directed**.
3. Air-Intake Louvers: Comply with requirements in Division 08 Section "Louvers And Vents".
4. Air-Intake Louvers **OR** Grille, **as directed**.
  - a. Louvers: Integral part of the housing, mechanically field adjustable and capable of reducing air-outlet velocity by 60 percent with louver in totally closed position.
  - b. Grille: Integral part of and same material as the housing.
  - c. Insect Screen: Aluminum **OR** Stainless steel, **as directed**, removable.
5. Fans
  - a. Centrifugal, forward curved, double width, double inlet **OR** Vane axial, **as directed**.
  - b. Galvanized steel **OR** Painted steel **OR** Aluminum, **as directed**.
  - c. Statically and dynamically balanced.
  - d. Direct drive **OR** Belt drive and equipped with belt guards and adjustable sheaves and pulleys for adjusting air-outlet velocity, **as directed**.
6. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - b. Single speed **OR** Two speed Multispeed, **as directed**.
  - c. Resiliently mounted.
  - d. Continuous duty.
  - e. Totally enclosed, air over **OR** totally enclosed, fan cooled, **OR**, open, dripproof **OR** explosion proof, **as directed**.
  - f. Integral thermal-overload protection.
  - g.
  - h. Bearings: Permanently sealed, lifetime, prelubricated, ball bearings.
  - i. Disconnect: Internal power cord with plug and receptacle.
7. Water Coils
  - a. Type: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**.
  - b. Piping Connections: Threaded on same end **OR** opposite ends, **as directed**.

- c. Tubes: Copper, complying with **ASTM B 75** (ASTM B 75M).
  - 1) Tube Diameter: **0.625 inch** (15.9 mm).
- d. Fins: Aluminum **OR** Copper, **as directed** with fin spacing **0.167 inch** (4.23 mm) **OR** **0.125 inch** (3.18 mm) **OR** **0.091 inch** (2.31 mm) **OR** **0.071 inch** (1.80 mm) **OR** **0.067 inch** (1.70 mm) **OR** **0.056 inch** (1.42 mm) **OR** **0.0075 inch** (0.19 mm), **as directed**.
- e. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
- f. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
- g. Frames: Galvanized-steel channel frame **0.052 inch** (1.3 mm) **OR** **0.064 inch** (1.6 mm) **OR** **0.079 inch** (2.0 mm) **OR** **0.0625 inch** (1.59 mm), **as directed**.
- h. Ratings: According to ASHRAE 33.
- i. Working-Pressure Ratings: **200 psig** (1380 kPa), **325 deg F** (163 deg C).
- 8. Steam Coils Distribution header coil **OR** Single-tube coil, **as directed** with threaded steam supply and condensate connections.
  - a. Piping Connections: Same end **OR** Opposite ends **OR** Steam supply on both ends; condensate on one end, **as directed**.
  - b. Tube Material: Copper, complying with **ASTM B 75** (ASTM B 75M).
  - c. Tube Diameter: **0.625 inch** (15.9 mm).
  - d. Fins: Aluminum **OR** Copper, **as directed** **0.167 inch** (4.23 mm) **OR** **0.125 inch** (3.18 mm) **OR** **0.091 inch** (2.31 mm) **OR** **0.071 inch** (1.80 mm) **OR** **0.067 inch** (1.70 mm) **OR** **0.056 inch** (1.42 mm) **OR** **0.0075 inch** (0.19 mm), **as directed**.
  - e. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
  - f. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
  - g. Frames: Galvanized-steel channel frame, **0.052 inch** (1.3 mm) **OR** **0.064 inch** (1.6 mm) **OR** **0.079 inch** (2.0 mm) **OR** **0.0625 inch** (1.59 mm), **as directed**.
  - h. Pressure and Temperature Ratings: **100 psig** (690 kPa), **400 deg F** (205 deg C) according to ASHRAE 33.
- 9. Electric-Resistance Coils:
  - a. Coil Assembly: Comply with UL 1995.
  - b. Frame: Galvanized-steel frame.
  - c. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.
  - d. Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
  - e. Overtemperature Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or unit.
    - 1) Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
  - f. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection. Include the following controls:
    - 1) Magnetic contactor.
    - 2) Mercury contactor.
    - 3) Solid-state stepless pulse controller.
    - 4) Toggle switches; one per step.
    - 5) Step controller.
    - 6) Time-delay relay.
    - 7) Pilot lights; one per step.
    - 8) Airflow proving switch.
- 10. Gas-Fired Heaters:
  - a. Comply with ANSI Z83.8/CSA, "Gas Unit Heaters and Gas-Fired Duct Furnaces."
    - 1) CSA Approval: Bear AGA label.

- 2) Type of Gas: Natural **OR** LP, **as directed**.
- b. Assembly and Wiring: Heaters factory assembled, piped, wired, and tested for 120-V ac.
- c. Housing: Steel, with integral draft hood and inserts for suspension-mounting rods.
- d. External Casings and Cabinets: Baked enamel over corrosion-resistant-treated surface.
- e. Heat Exchanger: Aluminized **OR** Stainless, **as directed**, steel.
- f. Burners: Cast iron or aluminized steel with stainless-steel inserts.
- g. Gravity vent.
- h. Power Venter: 120-V ac, with stainless-steel shaft.
- i. Automatic Gas Control: Single **OR** 2-stage, **as directed**, 24-V ac valve.
- j. Ignition: Standing pilot **OR** Electronically controlled spark with flame sensor, **as directed**.
11. Filters:
  - a. Disposable Panel Filters: Factory-fabricated, viscous-coated, flat-panel-type, disposable air filters with glass-fiber media sprayed with nonflammable adhesive in cardboard **OR** galvanized-steel, **as directed**, frame.
  - b. Washable Panel Filters: Removable, stainless-steel, baffle-type filters with spring-loaded fastening; with minimum **0.0781-inch- (1.984-mm-)** thick, stainless-steel filter frame.
  - c. Mounting Frames: Welded, galvanized steel with gaskets and fasteners and suitable for bolting together into built-up filter banks.
12. Controls:
  - a. Built-in **OR** Field-Installed, **as directed**, Thermostat: Line voltage, factory installed and wired to the junction box on air curtain **OR** motor-control panel, **as directed**.
  - b. Automatic Door Switch: Plunger type installed in door area to activate air curtain when door opens and to deactivate air curtain when door closes.
  - c. Start-Stop, Push-Button Switch: Manually activates and deactivates air curtain.
  - d. Three-Speed Switch: Manually activates, deactivates, and controls air-curtain fan speed.
  - e. Time-Delay Relay: Factory installed and adjustable to allow air curtain to operate from 0.5 seconds to 10 hours.
  - f. Motor-Control Panel: Complete with motor starter, 115-V ac transformer with primary and secondary fuses, terminal strip, and NEMA 250, Type 1 **OR** 12, **as directed**, enclosure.
13. Accessories:
  - a. Mounting Brackets: Adjustable mounting brackets for drum-type roll-up doors.
  - b. Discharge Extension Neck: For ceiling-recessed installation.
- B. Source Quality Control
  1. Source Quality Control: Test to **300 psig (2070 kPa)** and to **200 psig (1380 kPa)** underwater.
  2. Testing: Test and inspect steam coils according to ASHRAE 33.
  3. Steam coils will be considered defective if it does not pass tests and inspections.
  4. Prepare test and inspection reports.

### 1.3 EXECUTION

- A. Examination
  1. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance.
  2. Examine roughing-in for hot-water **OR** steam **OR** gas, **as directed**, piping systems to verify actual locations of piping connections before air-curtain installation.
  3. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Installation
  1. Install air curtains with clearance for equipment service and maintenance.
  2. Equipment Installation: Install air curtains with seismic-restraint devices. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

3. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
- C. Connections
  1. Comply with requirements for piping specified in Division 26 Section "Grounding And Bonding For Electrical Systems" and Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
  2. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
  3. Breaching: Comply with applicable requirements in Division 23 Section "Breechings, Chimneys, And Stacks". Connect breaching to full size at flue outlet.
- D. Field Quality Control
  1. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  2. Tests and Inspections:
    - a. After installing air curtains completely, perform visual and mechanical check of individual components.
    - b. After electrical circuitry has been energized, start unit to confirm motor rotation and unit operation. Certify compliance with test parameters.
    - c. Inspect for water leaks.
    - d. Test gas train and verify that there are no gas leaks.
    - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  3. Air-curtain unit will be considered defective if it does not pass tests and inspections.
  4. Prepare test and inspection reports.
- E. Adjusting
  1. Adjust belt tension.
  2. Adjust motor and fan speed to achieve specified airflow.
  3. Adjust discharge louver and dampers to regulate airflow.
  4. Adjust air-directional vanes.

END OF SECTION 23 34 33 00

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Task	Specification	Specification Description
23 35 13 13	01 22 16 00	No Specification Required
23 35 16 16	23 31 13 16	Tailpipe Exhaust Equipment

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## SECTION 23 36 13 00 - DIFFUSERS, REGISTERS, AND GRILLES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for diffusers, registers and grilles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Round ceiling diffusers.
  - b. Rectangular and square ceiling diffusers.
  - c. Perforated diffusers.
  - d. Louver face diffusers.
  - e. Linear bar diffusers.
  - f. Linear slot diffusers.
  - g. Ceiling-integral continuous diffusers.
  - h. Light troffer diffusers.
  - i. Round induction diffusers.
  - j. Linear floor diffuser plenums.
  - k. Drum louvers.
  - l. Modular core supply grilles.
  - m. Continuous tubular diffusers.
  - n. Adjustable bar registers and grilles.
  - o. Security registers and grilles.
  - p. Fixed face registers and grilles.
  - q. Linear bar grilles.

#### C. Submittals

1. Product Data: For each type of product indicated, include the following:
  - a. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static-pressure drop, and noise ratings.
  - b. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
2. Samples: For each exposed product and for each color and texture specified.

### 1.2 PRODUCTS

#### A. Ceiling Diffusers

1. Round Ceiling Diffuser:
  - a. Devices shall be specifically designed for variable-air-volume flows.
  - b. Material: Steel **OR** Aluminum, **as directed**.
  - c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
  - d. Face Style: Four **OR** Three **OR** Two, **as directed**, cone.
  - e. Mounting: Duct connection.
  - f. Pattern: Fully adjustable **OR** Two-position horizontal, **as directed**.
  - g. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
  - h. Accessories:
    - 1) Equalizing grid.

- 2) Plaster ring.
  - 3) Safety chain.
  - 4) Wire guard.
  - 5) Sectorizing baffles.
  - 6) Operating rod extension.
2. Rectangular and Square Ceiling Diffusers:
- a. Devices shall be specifically designed for variable-air-volume flows.
  - b. Material: Steel **OR** Aluminum, **as directed**.
  - c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
  - d. Face Size: **24 by 24 inches (600 by 600 mm) OR 20 by 20 inches (500 by 500 mm) OR 12 by 12 inches (300 by 300 mm), as directed.**
  - e. Face Style: Three cone **OR** Four cone **OR** Plaque, **as directed**.
  - f. Mounting: Surface **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
  - g. Pattern: Fixed **OR** Two position **OR** Adjustable, **as directed**.
  - h. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
  - i. Accessories:
    - 1) Equalizing grid.
    - 2) Plaster ring.
    - 3) Safety chain.
    - 4) Wire guard.
    - 5) Sectorizing baffles.
    - 6) Operating rod extension.
3. Perforated Diffuser:
- a. Devices shall be specifically designed for variable-air-volume flows.
  - b. Material: Steel backpan and pattern controllers, with steel **OR** aluminum, **as directed**, face.
  - c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
  - d. Face Size: **12 by 12 inches (300 by 300 mm) OR 24 by 12 inches (600 by 300 mm) OR 36 by 12 inches (900 by 300 mm) OR 48 by 12 inches (1200 by 300 mm) OR 16 by 16 inches (400 by 400 mm) OR 20 by 20 inches (500 by 500 mm) OR 24 by 24 inches (600 by 600 mm) OR 36 by 24 inches (900 by 600 mm) OR 48 by 24 inches (1200 by 600 mm), as directed.**
  - e. Duct Inlet: Round **OR** Square, **as directed**.
  - f. Face Style: Flush **OR** Drop extended, **as directed**.
  - g. Mounting: Surface **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
  - h. Pattern Controller: Four louvered deflector patches **OR** Fixed with curved blades at inlet **OR** Adjustable with louvered pattern modules at inlet **OR** None, **as directed**.
  - i. Dampers: Opposed blade **OR** Radial opposed blade **OR** Butterfly **OR** Combination damper and grid **OR** Combination volume and fire, **as directed**.
  - j. Accessories:
    - 1) Equalizing grid.
    - 2) Plaster ring.
    - 3) Safety chain.
    - 4) Wire guard.
    - 5) Sectorizing baffles.
    - 6) Operating rod extension.
4. Louver Face Diffuser:
- a. Devices shall be specifically designed for variable-air-volume flows.
  - b. Material: Steel **OR** Aluminum, **as directed**.
  - c. Finish: Baked enamel, white **OR** Baked enamel, color selected **OR** Anodized aluminum, **as directed**.
  - d. Face Size: as directed by the Owner.

- e. Mounting: Surface **OR** Surface with beveled frame **OR** T-bar **OR** Snap in **OR** Spline **OR** Mounting panel, **as directed**.
- f. Pattern: One-way **OR** Two-way **OR** Two-way corner **OR** Three-way **OR** Four-way **OR** Adjustable, **as directed**, core style.
- g. Dampers: Radial opposed blade **OR** Butterfly **OR** Combination damper and grid, **as directed**.
- h. Accessories:
  - 1) Square to round neck adaptor.
  - 2) Adjustable pattern vanes.
  - 3) Throw reducing vanes.
  - 4) Equalizing grid.
  - 5) Plaster ring.
  - 6) Safety chain.
  - 7) Wire guard.
  - 8) Sectorizing baffles.
  - 9) Operating rod extension.

B. Ceiling Linear Slot Outlets

1. Linear Bar Diffuser:

- a. Devices shall be specifically designed for variable-air-volume flows.
- b. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
- c. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
- d. Narrow Core Spacing Arrangement: ~~1/8-inch- (3-mm-)~~ thick blades spaced ~~1/4 inch (6 mm)~~ apart, zero **OR** 15, **as directed**, -degree deflection.
- e. Wide Core Spacing Arrangement: ~~1/8-inch- (3-mm-)~~ thick blades spaced ~~1/2 inch (13 mm)~~ apart, zero **OR** 15, **as directed**, -degree deflection.
- f. Wide Core Spacing Arrangement: ~~3/16-inch- (5-mm-)~~ thick blades spaced ~~1/2 inch (13 mm)~~ apart, zero **OR** 15 **OR** 30, **as directed**, -degree deflection.
- g. Pencil-Proof Core Spacing Arrangement: ~~3/16-inch- (5-mm-)~~ thick blades spaced ~~7/16 inch (11 mm)~~ apart, zero **OR** 15 **OR** 30, **as directed**, -degree deflection.
- h. One **OR** Two, **as directed**, -Way Deflection Vanes: Extruded construction fixed louvers with removable core.
- i. Frame: ~~1-1/4 inches (32 mm)~~ **OR** ~~1 inch (25 mm)~~ **OR** ~~3/4 inch (19 mm)~~ **OR** ~~1/2 inch (13 mm)~~ **OR** ~~3/16 inch (5 mm)~~, **as directed**, wide.
- j. Mounting Frame: Filter.
- k. Mounting: Countersunk screw **OR** Concealed bracket **OR** Spring clip, **as directed**.
- l. Damper Type: Adjustable opposed-blade assembly **OR** Hinged single blade, **as directed**.
- m. Accessories: Plaster frame **OR** Directional vanes **OR** Alignment pins **OR** Core clips **OR** Blank-off strips, **as directed**.

2. Linear Slot Diffuser:

- a. Devices shall be specifically designed for variable-air-volume flows.
- b. Material - Shell: Steel **OR** Aluminum, **as directed**, insulated **OR** noninsulated, **as directed**.
- c. Material - Pattern Controller and Tees: Aluminum.
- d. Finish - Face and Shell: Baked enamel, black.
- e. Finish - Pattern Controller: Baked enamel, black.
- f. Finish - Tees: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
- g. Slot Width: ~~1/2 inch (13 mm)~~ **OR** ~~3/4 inch (19 mm)~~ **OR** ~~1 inch (25 mm)~~ **OR** ~~1-1/2 inches (38 mm)~~, **as directed**.
- h. Number of Slots: One **OR** Two **OR** Three **OR** Four, **as directed**.
- i. Length: ~~24 inches (600 mm)~~ **OR** ~~30 inches (750 mm)~~ **OR** ~~36 inches (900 mm)~~ **OR** ~~48 inches (1200 mm)~~ **OR** ~~60 inches (1500 mm)~~, **as directed**.
- j. Accessories: Plaster frame **OR** T-bar slot **OR** Center notch **OR** T-bar on inlet side **OR** T-bar on both sides **OR** T-bar clip on one side **OR** T-bar clips on both sides, **as directed**.

3. Ceiling-Integral Continuous Diffuser:

- a. Slot Width: **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 2-1/2 inches (63 mm) OR 3 inches (76 mm), as directed.**
  - b. Section Length: **12 feet (3.7 m).**
  - c. Straight and curved sections as required to accommodate layout.
  - d. Mitered tees and corners.
  - e. Pattern Controllers: **24 inches (600 mm) o.c.**
  - f. Material: Aluminum, extruded, heavy wall.
  - g. Finishes:
    - 1) Exterior: Standard white.
    - 2) Interior: Standard black.
  - h. Throw: Standard **OR** High, **as directed.**
  - i. Mounting: Ceiling **OR** Sidewall, **as directed.**
  - j. Plenum: Noninsulated **OR** Insulated, **as directed.**
  - k. Other Features:
    - 1) Painted interior.
    - 2) Blank-offs.
4. Light Troffer Diffuser:
- a. Devices shall be specifically designed for variable-air-volume flows.
  - b. Material: Steel with external insulation, **as directed.**
  - c. Finish: None **OR** Black enamel on visible surfaces, **as directed.**
  - d. Slot Width: **1/2 inch (13 mm) OR 3/4 inch (19 mm) OR 1 inch (25 mm) OR 1-1/2 inches (38 mm), as directed.**
  - e. Number of Sides: One **OR** Two, **as directed.**
  - f. Length: **24 inches (600 mm) OR 36 inches (900 mm) OR 48 inches (1200 mm), as directed.**
  - g. Pattern: Fixed **OR** Adjustable, **as directed.**
  - h. Inlet: Top **OR** Side, **as directed.**
  - i. Inlet Size: **5 inches (125 mm) OR 6 inches (150 mm) OR 8 inches (200 mm), as directed.**
- C. Underfloor Air Distribution Diffusers
1. Round Induction Diffusers:
    - a. Airflow Principle: Swirl-pattern induction.
    - b. Material: Plastic, high impact, and resistant to cart and foot traffic.
    - c. Color: Gray **OR** Black, **as directed.**
    - d. Components:
      - 1) Diffuser core.
      - 2) Flow regulator.
      - 3) Dirt and liquid catch pan.
      - 4) Spacer flange.
      - 5) Gasketed, underfloor compression ring.
  2. Linear Floor Diffuser Plenums:
    - a. Material: Steel.
    - b. Finish: White baked acrylic.
    - c. Deflection: Zero **OR** 15, **as directed**, degrees.
    - d. Components:
      - 1) Aluminum diffuser core.
      - 2) Diffuser frame.
      - 3) Plenum, **0.034-inch (0.85-mm) steel.**
- D. High-Capacity Diffusers
1. Drum Louver:
    - a. Airflow Principle: Extended distance for high airflow rates.
    - b. Material: Aluminum, heavy gage extruded.
    - c. Finish: White baked acrylic.
    - d. Border: **1-1/4-inch (32-mm) width with countersunk screw holes.**

- e. Gasket between drum and border.
  - f. Body: Drum shaped; adjustable vertically.
  - g. Blades: Individually adjustable horizontally.
  - h. Mounting: Surface to duct **OR** wall, **as directed**.
  - i. Inlet Width: **6 inches (150 mm) OR 10 inches (250 mm) OR 12 inches (300 mm) OR 15 inches (380 mm), as directed.**
  - j. Inlet Length: **12 inches (300 mm) OR 24 inches (600 mm) OR 36 inches (900 mm) OR 60 inches (1500 mm), as directed.**
  - k. Accessories:
    - 1) Opposed-blade steel damper.
    - 2) Duct-mounting collars with countersunk screw holes.
  - 2. Modular Core Supply Grilles:
    - a. Throw: Extended distance for airflow rates.
    - b. Material: Steel.
    - c. Grilles per Unit: One **OR** Two **OR** Three **OR** Four, **as directed**.
    - d. Finish: White baked acrylic.
    - e. Border: **1-1/2-inch (38-mm)** width with countersunk screw holes.
    - f. Blades:
      - 1) Airfoil, individually adjustable horizontally.
      - 2) Double deflection.
      - 3) Set in modules.
    - g. Modules: Removable; rotatable.
    - h. Mounting: Surface.
    - i. Accessory: Opposed-blade steel damper.
- E. Flexible Diffusion Outlets
- 1. Continuous Tubular Diffuser:
    - a. Material: Flame-retardant, woven polyethylene fabric **OR** Flame-retardant, coated polyester and fiberglass fabric **OR** Flame-retardant, permeable polyester and fiberglass fabric **OR** Polyethylene, **as directed**.
    - b. Duct Connection: Round.
    - c. Duct Connection Size: **as directed** by the Owner.
    - d. Diffusion Hole Size: **as directed** by the Owner.
    - e. Diffusion Hole Frequency - Number per **100 Feet (30 m): <Insert number>**.
    - f. Accessories:
      - 1) Quick-connect joint.
      - 2) Snap hooks.
      - 3) Cleanout zipper.
      - 4) Condensate drain.
- F. Registers And Grilles
- 1. Adjustable Bar Register:
    - a. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
    - b. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
    - c. Face Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced **3 inches (76 mm) OR 1-1/2 inches (38 mm) OR 3/4 inch (19 mm) OR 1/2 inch (13 mm), as directed**, apart.
    - d. Core Construction: Integral **OR** Removable, **as directed**.
    - e. Rear-Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced **3/4 inch (19 mm) OR 1/2 inch (13 mm), as directed**, apart.
    - f. Frame: **1-1/4 inches (32 mm) OR 1 inch (25 mm), as directed**, wide.
    - g. Mounting Frame: Filter.
    - h. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
    - i. Damper Type: Adjustable opposed blade **OR** NRTL listed, opposed blade, spring closing, and with fusible link for **160 deg F (71 deg C), as directed**.
    - j. Accessories:
      - 1) Front **OR** Rear, **as directed**, -blade gang operator.



- 2) Filter.
2. Adjustable Bar Grille:
  - a. Material: Steel **OR** Aluminum **OR** Stainless steel, **as directed**.
  - b. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
  - c. Face Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced **3 inches (76 mm)** **OR 1-1/2 inches (38 mm)** **OR 3/4 inch (19 mm)** **OR 1/2 inch (13 mm)**, **as directed**, apart.
  - d. Core Construction: Integral **OR** Removable, **as directed**.
  - e. Rear-Blade Arrangement: Horizontal **OR** Vertical, **as directed**, spaced **3/4 inch (19 mm)** **OR 1/2 inch (13 mm)**, **as directed**, apart.
  - f. Frame: **1-1/4 inches (32 mm)** **OR 1 inch (25 mm)**, **as directed**, wide.
  - g. Mounting Frame: Filter.
  - h. Mounting: Countersunk screw **OR** Concealed **OR** Lay in, **as directed**.
3. Security Register:
  - a. Security Level: Maximum **OR** Medium **OR** Minimum, **as directed**, and suicide deterrent, **as directed**.
  - b. Application: Ducted return **OR** Air transfer **OR** Barrier, **as directed**.
  - c. Material: Steel **OR** Aluminum, **as directed**.
  - d. Material Thickness: **0.19 inch (4.8 mm)**.
  - e. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
  - f. Face Arrangement:
    - 1) Shape: Square **OR** Rectangular **OR** Round, **as directed**.
    - 2) Design: Fixed bar **OR** Perforated **OR** Lattice, **as directed**.
    - 3) Frame: Yes **OR** No, **as directed**.
    - 4) Deflection: Zero **OR** 38, **as directed**, degrees.
    - 5) Core: None **OR** Louvered, **as directed**.
    - 6) **3/16-inch- (5-mm-)** thick, front lattice plate with **2-by-2-inch- (50-by-50-mm-)** square holes and **1-inch (25-mm)** frets, **0.135-inch (3.43-mm)** wire mesh, and **1/4-inch- (6-mm-)** thick backer plate.
    - 7) **3/16-inch- (5-mm-)** thick, perforated faceplate with **5/16-inch- (8-mm-)** diameter holes spaced **7/16 inch (11 mm)** o.c., staggered at 60 degrees.
    - 8) **1-1/2-inch (38-mm)** bars and mandrel tubes and rods with zero **OR** 15, **as directed**, -degree deflection in **1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm)** angle border.
    - 9) **1-3/8-inch (35-mm)** bars and double mandrel tubes with zero **OR** 15, **as directed**, -degree deflection in **1-3/4-inch (45-mm)** angle border.
  - g. Damper Operation: None **OR** Face operated **OR** Rear operated, **as directed**.
  - h. Damper Type: Adjustable opposed blade **OR** NRTL listed, opposed blade, spring closing, and with fusible link for **160 deg F (71 deg C)**, **as directed**.
  - i. Wall Sleeve: **3/16 inch (5 mm)** welded to face **OR 1/8 inch (3 mm)** welded to face **OR** Mechanically fastened to border, **as directed**.
  - j. Mounting: **1-by-1-by-3/16-inch (25-by-25-by-5-mm)** retaining angle frame **OR 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm)** retaining angle frame **OR 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm)** cast-in-place frame and tamperproof machine screws, **as directed**.
4. Security Grille:
  - a. Security Level: Maximum **OR** Medium **OR** Minimum, **as directed**, and suicide deterrent, **as directed**.
  - b. Application: Ducted return **OR** Air transfer **OR** Barrier, **as directed**.
  - c. Material: Steel **OR** Aluminum, **as directed**.
  - d. Material Thickness: **0.19 inch (4.8 mm)**.
  - e. Finish: Baked enamel, white **OR** Baked enamel, color selected, **as directed**.
  - f. Face Arrangement:
    - 1) Shape: Square **OR** Rectangular **OR** Round, **as directed**.
    - 2) Design: Fixed bar **OR** Perforated **OR** Lattice, **as directed**.
    - 3) Frame: Yes **OR** No, **as directed**.
    - 4) Deflection: Zero **OR** 38, **as directed**, degrees.
    - 5) Core: None **OR** Louvered, **as directed**.

- 6) **3/16-inch- (5-mm-)** thick, front lattice plate with **2-by-2-inch- (50-by-50-mm-)** square holes and **1-inch (25-mm)** frets, **0.135-inch (3.43-mm)** wire mesh, and **1/4-inch- (6-mm-)** thick backer plate.
- 7) **3/16-inch- (5-mm-)** thick perforated faceplate with **5/16-inch- (8-mm-)** diameter holes spaced **7/16 inch (11 mm)** o.c., staggered at 60 degrees.
- 8) **1-1/2-inch (38-mm)** bars and mandrel tubes and rods with zero **OR 15, as directed**, -degree deflection in **1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm)** angle border.
- 9) **1-3/8-inch (35-mm)** bars and double mandrel tubes with zero **OR 15, as directed**, -degree deflection in **1-3/4-inch (45-mm)** angle border.
- g. Wall Sleeve: **3/16 inch (5 mm)** welded to face **OR 1/8 inch (3 mm)** welded to face **OR Mechanically fastened to border, as directed**.
- h. Mounting: **1-by-1-by-3/16-inch (25-by-25-by-5-mm)** retaining angle frame **OR 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm)** retaining angle frame **OR 1-1/4-by-1-1/4-by-3/16-inch (32-by-32-by-5-mm)** cast-in-place frame and tamperproof machine screws, **as directed**.
5. Fixed Face Register:
  - a. Material: Steel **OR Aluminum, as directed**.
  - b. Finish: Baked enamel, white **OR Baked enamel, color selected, as directed**.
  - c. Face Arrangement: **1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm)** grid **OR Perforated, as directed, core**.
  - d. Core Construction: Integral **OR Removable, as directed**.
  - e. Frame: **1-1/4 inches (32 mm) OR 1 inch (25 mm), as directed**, wide.
  - f. Mounting Frame: Filter.
  - g. Mounting: Countersunk screw **OR Concealed OR Lay in, as directed**.
  - h. Damper Type: Adjustable opposed blade **OR NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), as directed**.
  - i. Accessory: Filter.
6. Fixed Face Grille:
  - a. Material: Steel **OR Aluminum, as directed**.
  - b. Finish: Baked enamel, white **OR Baked enamel, color selected**.
  - c. Face Arrangement: **1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm)** grid **OR Perforated, as directed, core**.
  - d. Core Construction: Integral **OR Removable, as directed**.
  - e. Frame: **1-1/4 inches (32 mm) OR 1 inch (25 mm), as directed**, wide.
  - f. Mounting Frame: Filter.
  - g. Mounting: Countersunk screw **OR Concealed OR Lay in, as directed**.
  - h. Accessory: Filter.
7. Linear Bar Grille:
  - a. Material: Steel **OR Aluminum, as directed**.
  - b. Finish: Baked enamel, white **OR Baked enamel, color selected, as directed**.
  - c. Face Arrangement: **1/2-by-1/2-by-1/2-inch (13-by-13-by-13-mm)** grid **OR Perforated, as directed, core**.
  - d. Distribution plenum.
    - 1) Internal insulation.
    - 2) Inlet damper.
  - e. Frame: **1-1/4 inches (32 mm) OR 1 inch (25 mm), as directed**, wide.
  - f. Mounting Frame: Filter.
  - g. Mounting: Countersunk screw **OR Concealed OR Lay in, as directed**.
  - h. Damper Type: Adjustable opposed blade **OR NRTL listed, opposed blade, spring closing, and with fusible link for 160 deg F (71 deg C), as directed**.
- G. Source Quality Control
  1. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

### 1.3 EXECUTION

#### A. Installation

1. Install diffusers, registers, and grilles level and plumb.
2. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify the Owner for a determination of final location.
3. Install diffusers, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

#### B. Adjusting

1. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 23 36 13 00

## SECTION 23 36 16 00 - AIR TERMINAL UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for air terminal units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Bypass, single-duct air terminal units.
  - b. Dual-duct air terminal units.
  - c. Fan-powered air terminal units.
  - d. Induction air terminal units.
  - e. Shutoff, single-duct air terminal units.
  - f. Diffuser-type air terminal units.

#### C. Performance Requirements

1. Structural Performance: Hangers and supports and seismic restraints, **as directed**, shall withstand the effects of gravity and seismic, **as directed**, loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and ASCE/SEI 7 **OR** SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems", **as directed**.
  - a. Seismic Hazard Level A: Seismic force to weight ratio, 0.48.
  - b. Seismic Hazard Level B: Seismic force to weight ratio, 0.30.
  - c. Seismic Hazard Level C: Seismic force to weight ratio, 0.15.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittal:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: For air terminal units. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
  - c. Hangers and supports, including methods for duct and building attachment, seismic restraints, and vibration isolation.
4. Delegated-Design Submittal:
  - a. Materials, fabrication, assembly, and spacing of hangers and supports.
  - b. Design Calculations: Calculations, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation, **as directed**, for selecting hangers and supports and seismic restraints, **as directed**.
5. Field quality-control reports.
6. Operation and maintenance data.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."

## 1.2 PRODUCTS

### A. Bypass, Single-Duct Air Terminal Units

1. Configuration: Diverting-damper assembly inside unit casing with control components inside a protective metal shroud.
2. Casing: **0.034-inch (0.85-mm)** steel **OR** **0.032-inch (0.8-mm)** aluminum, **as directed**, single **OR** double, **as directed**, wall.
  - a. Casing Lining: Adhesive attached, **1/2-inch- (13-mm-)** **OR** **3/4-inch- (19-mm-)** **OR** **1-inch- (25-mm-)**, **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    - 1) Cover liner with nonporous foil.
    - OR**
    - Cover liner with nonporous foil and perforated metal.
  - OR**
  - Casing Lining: Adhesive attached, **1/2-inch- (13-mm-)** **OR** **3/4-inch- (19-mm-)** **OR** **1-inch- (25-mm-)**, **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
  - b. Air Inlet: Round stub connection for duct attachment.
  - c. Air Outlet: S-slip and drive connections.
  - d. Access: Removable panels for access to diverting damper and other parts requiring service, adjustment, or maintenance; with airtight gasket.
  - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Diverter Assembly: Galvanized-steel gate, with polyethylene linear bearings **OR** Aluminum blade, with nylon-fitted pivot points, **as directed**.
4. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, **6-inch- (150-mm-)** **OR** **8-inch- (200-mm-)** **OR** **10-inch- (250-mm-)**, **as directed**, diameter collars, each with locking butterfly balancing damper.
5. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and rated for a minimum working pressure of **200 psig (1380 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain valve.
 

**OR**

Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

  - a. Access door interlocked disconnect switch.
  - b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
  - c. Nickel chrome 80/20 heating elements.
  - d. Airflow switch for proof of airflow.
  - e. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
  - f. Mercury contactors.
  - g. Pneumatic-electric switches and relays.
  - h. Magnetic contactor for each step of control (for three-phase coils).
6. Electric Controls: Damper actuator and thermostat.
  - a. Damper Actuator: 24 V, powered closed, powered open with microswitch to energize heating control circuit, **as directed**.
  - b. Thermostat: Wall-mounted electric type with temperature display in Fahrenheit and Celsius, and space temperature set point.

- c. Changeover Thermostat: Duct-mounted, field-adjustable, electric type reverses action of zone thermostat when air temperature reaches **70 deg F (21 deg C)**.

**OR**

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- d. Damper Actuator: 24 V, powered closed, powered open.
- e. Thermostat: Wall-mounted electronic type with the following features:
- 1) Temperature set-point display in Fahrenheit and Celsius.
  - 2) Auxiliary switch to energize heating control circuit.
  - 3) Changeover thermistor to reverse action.

**B. Dual-Duct Air Terminal Units**

1. Configuration: Two volume dampers inside unit casing with mixing attenuator section and control components inside a protective metal shroud with a third primary air inlet with volume damper, **as directed**.
2. Casing: **0.034-inch (0.85-mm) steel OR 0.032-inch (0.8-mm) aluminum, as directed**, single **OR** double, **as directed**, wall.
  - a. Casing Lining: Adhesive attached, **1/2-inch- (13-mm-) OR 3/4-inch- (19-mm-) OR 1-inch- (25-mm-), as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    - 1) Cover liner with nonporous foil.

**OR**

Cover liner with nonporous foil and perforated metal.

**OR**

Casing Lining: Adhesive attached, **1/2-inch- (13-mm-) OR 3/4-inch- (19-mm-) OR 1-inch- (25-mm-), as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
  - b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
  - c. Air Outlet: S-slip and drive connections.
  - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
  - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
  - a. Maximum Damper Leakage: ARI 880 rated, 3 percent of nominal airflow at **3-inch wg (750-Pa) OR 6-inch wg (1500-Pa), as directed**, inlet static pressure.
4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.
5. Attenuator Section: **0.034-inch (0.85-mm) steel OR 0.032-inch (0.8-mm) aluminum, as directed**, sheet.
  - a. Lining: Adhesive attached, **1/2-inch- (13-mm-) OR 3/4-inch- (19-mm-) OR 1-inch- (25-mm-), as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    - 1) Cover liner with nonporous foil.

**OR**

Cover liner with nonporous foil and perforated metal.

**OR**

Lining: Adhesive attached, **3/4-inch- (19-mm-)** thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index





- of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
- b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
  6. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, 6-inch- (150-mm-) **OR** 8-inch- (200-mm-) **OR** 10-inch- (250-mm-) **OR** 12-inch- (300-mm-), **as directed**, diameter collars, each with locking butterfly balancing damper.
  7. Pneumatic Controls: Damper operator, velocity controllers, and thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:
    - a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
    - b. Velocity Controllers: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor. Locate velocity sensors in cold- and hot-deck **OR** cold-, hot-, and ventilation- deck **OR** cold-deck, **as directed**, air inlets and supply air outlets.
    - c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

**OR**

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

    - a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
    - b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor. Locate velocity sensors in cold-deck air inlets and air outlets.
    - c. Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius, **as directed**.

**OR**

Direct Digital Controls: Single-package unitary controller and actuator specified in Division 23 Section "Instrumentation And Control For Hvac"

**OR**

Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

    - d. Damper Actuators: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
    - e. Terminal Unit Controller: Pressure-independent, variable-air **OR** constant, **as directed**, -volume controller with electronic airflow transducers factory calibrated to minimum and maximum air volumes, and having the following features:
      - 1) Occupied and unoccupied operating mode.
      - 2) Remote reset of airflow or temperature set points.
      - 3) Adjusting and monitoring with portable terminal.
      - 4) Communication with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
    - f. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.  - 8. Control Sequence:
    - a. Modulate cold-air damper to maintain room temperature.
    - b. Modulate warm-air damper to maintain constant airflow.

### C. Parallel Fan-Powered Air Terminal Units



1. Configuration: Volume-damper assembly and fan in parallel arrangement inside unit casing with control components inside a protective metal shroud.
2. Casing: **0.034-inch (0.85-mm) steel OR 0.032-inch (0.8-mm) aluminum, as directed, single OR double, as directed, wall.**
  - a. Casing Lining: Adhesive attached, **1/2-inch- (13-mm-) OR 3/4-inch- (19-mm-) OR 1-inch- (25-mm-), as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    - 1) Cover liner with nonporous foil.  
**OR**  
Cover liner with nonporous foil and perforated metal.
  - OR**  
Casing Lining: Adhesive attached, **1/2-inch- (13-mm-) OR 3/4-inch- (19-mm-) OR 1-inch- (25-mm-), as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
  - b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
  - c. Air Outlet: S-slip and drive connections.
  - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
  - e. Fan: Forward-curved centrifugal, located at plenum air inlet.
  - f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
  - a. Maximum Damper Leakage: ARI 880 rated, **2 OR 3, as directed**, percent of nominal airflow at **3-inch wg (750-Pa) OR 6-inch wg (1500-Pa), as directed**, inlet static pressure.
  - b. Damper Position: Normally open **OR** closed, **as directed**.
4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.
5. Motor:
  - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - b. Type: Permanent-split capacitor with SCR for speed adjustment **OR** Electronically commutated motor, **as directed**.
  - c. Fan-Motor Assembly Isolation: Rubber isolators.
  - d. Enclosure: Open dripproof **OR** Totally enclosed, fan cooled **OR** Totally enclosed, air over **OR** Open, externally ventilated **OR** Totally enclosed, nonventilated **OR** Severe duty **OR** Explosion proof **OR** Dust-ignition-proof machine, **as directed**.
  - e. Enclosure Materials: Cast iron **OR** Cast aluminum **OR** Rolled steel, **as directed**.
6. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
  - a. Material: Polyurethane foam having 70 percent arrestance and 3 MERV.  
**OR**  
Material: Glass fiber treated with adhesive; having 80 percent arrestance and 5 MERV.  
**OR**  
Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
  - b. Thickness: **2 inches (50 mm) OR 1 inch (25 mm), as directed**.
7. Attenuator Section: **0.034-inch (0.85-mm) steel OR 0.032-inch (0.8-mm) aluminum, as directed, sheet.**
  - a. Lining: Adhesive attached, **1/2-inch- (13-mm-) OR 3/4-inch- (19-mm-) OR 1-inch- (25-mm-), as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and

having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.

- 1) Cover liner with nonporous foil.

**OR**

Cover liner with nonporous foil and perforated metal.

- b. Lining: Adhesive attached, **3/4-inch- (19-mm-)** thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
  - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
8. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and rated for a minimum working pressure of **200 psig (1380 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain valve.
- a. Location: Plenum air inlet.
- OR**
- Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
- a. Location: Plenum air inlet.
  - b. Stage(s): **1 OR 2 OR 3, as directed.**
  - c. Access door interlocked disconnect switch.
  - d. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
  - e. Nickel chrome 80/20 heating elements.
  - f. Airflow switch for proof of airflow.
  - g. Fan interlock contacts.
  - h. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
  - i. Mercury contactors.
  - j. Pneumatic-electric switches and relays.
  - k. Magnetic contactor for each step of control (for three-phase coils).
9. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.
- a. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
  - b. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
  - c. Disconnect Switch: Factory-mounted, fuse type.
10. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
11. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.

**OR**

Pneumatic Controls: Damper operator, velocity controller, and thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Pneumatic Damper Operator: **0- to 13-psig (0- to 90-kPa)** spring range.
- b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while pressure independent up to **4-inch wg (1000 Pa)**; and shall have a multipoint velocity sensor at air inlet.
- c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

**OR**

Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Occupied and unoccupied operating mode.
- b. Remote reset of airflow or temperature set points.
- c. Adjusting and monitoring with portable terminal.
- d. Communication with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".

12. Control Sequence:

- a. Occupied (Primary Airflow On):
  - 1) Operate as throttling control for cooling.
  - 2) As cooling requirement decreases, control valve throttles toward minimum airflow.
  - 3) As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps, **as directed**.
- b. Unoccupied (Primary Airflow Off):
  - 1) When pressure at primary inlet is zero or less, fan is de-energized.
  - 2) As heating requirement increases, fan energizes to draw in warm plenum air and electric heat is energized in steps, **as directed**.

D. Series Fan-Powered Air Terminal Units

1. Configuration: Volume-damper assembly and fan in series arrangement inside unit casing with control components inside a protective metal shroud for installation above a ceiling and within a raised access floor, **as directed**.
2. Casing: **0.034-inch (0.85-mm) steel OR 0.032-inch (0.8-mm) aluminum, as directed, single OR double, as directed, wall.**
  - a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR 3/4-inch- (19-mm-) OR 1-inch- (25-mm-), as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    - 1) Cover liner with nonporous foil.
    - OR**
    - Cover liner with nonporous foil and perforated metal.
  - OR**
  - Casing Lining: Adhesive attached, **1/2-inch- (13-mm-) OR 3/4-inch- (19-mm-) OR 1-inch- (25-mm-), as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
  - b. Air Inlets: Round stub connections or S-slip and drive connections for duct attachment.
  - c. Air Outlet: S-slip and drive connections.
  - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
  - e. Fan: Forward-curved centrifugal.
  - f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with flow-sensing ring and peripheral gasket and self-lubricating bearings.
  - a. Maximum Damper Leakage: ARI 880 rated, **2 OR 3, as directed**, percent of nominal airflow at **3-inch wg (750-Pa) OR 6-inch wg (1500-Pa), as directed**, inlet static pressure.
  - b. Damper Position: Normally open **OR** closed, **as directed**.
4. Velocity Sensors: Multipoint array with velocity sensors in cold- and hot-deck air inlets and air outlets.
5. Motor:



- a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- b. Type: Permanent-split capacitor with SCR for speed adjustment **OR** Electronically commutated motor, **as directed**.
- c. Fan-Motor Assembly Isolation: Rubber isolators.
- d. Enclosure: Open dripproof **OR** Totally enclosed, fan cooled **OR** Totally enclosed, air over **OR** Open, externally ventilated **OR** Totally enclosed, nonventilated **OR** Severe duty **OR** Explosion proof **OR** Dust-ignition-proof machine, **as directed**.
- e. Enclosure Materials: Cast iron **OR** Cast aluminum **OR** Rolled steel, **as directed**.
6. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
  - a. Material: Polyurethane foam having 70 percent arrestance and 3 MERV.  
**OR**  
Material: Glass fiber treated with adhesive; having 80 percent arrestance and 5 MERV.  
**OR**  
Material: Pleated cotton-polyester media having 90 percent arrestance and 7 MERV.
  - b. Thickness: 2 inches (50 mm) **OR** 1 inch (25 mm), **as directed**.
7. Attenuator Section: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, sheet.
  - a. Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    - 1) Cover liner with nonporous foil.  
**OR**  
Cover liner with nonporous foil and perforated metal.  
**OR**  
Lining: Adhesive attached, 3/4-inch- (19-mm-) thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
  - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
8. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch (2.5 mm), and rated for a minimum working pressure of 200 psig (1380 kPa) and a maximum entering-water temperature of 220 deg F (104 deg C). Include manual air vent and drain valve.  
**OR**  
Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
  - a. Stage(s): 1 **OR** 2 **OR** 3, **as directed**.
  - b. Access door interlocked disconnect switch.
  - c. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
  - d. Nickel chrome 80/20 heating elements.
  - e. Airflow switch for proof of airflow.
  - f. Fan interlock contacts.
  - g. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
  - h. Mercury contactors.
  - i. Pneumatic-electric switches and relays.
  - j. Magnetic contactor for each step of control (for three-phase coils).
9. Factory-Mounted and -Wired Controls: Electrical components mounted in control box with removable cover. Incorporate single-point electrical connection to power source.

- a. Control Transformer: Factory mounted for control voltage on electric and electronic control units with terminal strip in control box for field wiring of thermostat and power source.
- b. Wiring Terminations: Fan and controls to terminal strip. Terminal lugs to match quantities, sizes, and materials of branch-circuit conductors. Enclose terminal lugs in terminal box that is sized according to NFPA 70.
- c. Disconnect Switch: Factory-mounted, fuse type.
- 10. Control Panel Enclosure: NEMA 250, Type 1, with access panel sealed from airflow and mounted on side of unit.
- 11. Electric Controls: 24-V damper actuator with wall-mounted electric thermostat and appropriate mounting hardware.

**OR**

Pneumatic Controls: Damper operator, velocity controller, and thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Pneumatic Damper Operator: 0- to 13-psig (0- to 90-kPa) spring range.
- b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while pressure independent up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
- c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

**OR**

Electronic Controls: Bidirectional damper operator and microprocessor-based controller with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Occupied and unoccupied operating mode.
- b. Remote reset of airflow or temperature set points.
- c. Adjusting and monitoring with portable terminal.
- d. Communication with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
- 12. Control Sequence:
  - a. Occupied (Primary Airflow On):
    - 1) When pressure at inlet is at least 1.2-inch wg (300 Pa).
    - 2) As cooling requirement decreases, control valve throttles toward minimum airflow.
  - b. Unoccupied (Primary Airflow Off):
    - 1) When pressure at primary inlet is zero or less, fan is de-energized.

**E. Induction Air Terminal Units**

- 1. Configuration: Volume-damper assembly inside unit casing with mechanical induction damper mounted on casing and control components inside a protective metal shroud.
  - 2. Casing: 0.034-inch (0.85-mm) steel **OR** 0.032-inch (0.8-mm) aluminum, **as directed**, single **OR** double, **as directed**, wall.
    - a. Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
      - 1) Cover liner with nonporous foil.
- OR**
- Cover liner with nonporous foil and perforated metal.
- OR**
- Casing Lining: Adhesive attached, 1/2-inch- (13-mm-) **OR** 3/4-inch- (19-mm-) **OR** 1-inch- (25-mm-), **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.





- b. Air Inlet: Round stub connection for duct attachment.
  - c. Air Outlet: S-slip and drive connections, size matching inlet size, **as directed**.
  - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
  - e. Fan: Forward-curved centrifugal.
  - f. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
- a. Maximum Damper Leakage: ARI 880 rated, 2 **OR** 3, **as directed**, percent of nominal airflow at **3-inch wg (750-Pa) OR 6-inch wg (1500-Pa)**, **as directed**, inlet static pressure.
  - b. Damper Position: Normally open **OR** closed, **as directed**.
4. Induction Damper: Galvanized-steel, multiblade assembly with self-lubricating bearings.
5. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and rated for a minimum working pressure of **200 psig (1380 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain valve.
- OR**
- Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.
- a. Access door interlocked disconnect switch.
  - b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
  - c. Nickel chrome 80/20 heating elements.
  - d. Airflow switch for proof of airflow.
  - e. Fan interlock contacts.
  - f. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
  - g. Mercury contactors.
  - h. Pneumatic-electric switches and relays.
  - i. Magnetic contactor for each step of control (for three-phase coils).
6. Pneumatic Controls: Damper operator, velocity controller, and induction damper operator. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:
- a. Damper Operator: Pneumatic, **0- to 13-psig (0- to 90-kPa)** spring range.
  - b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to **4-inch wg (1000 Pa)**; and shall have a multipoint velocity sensor at air inlet.
  - c. Induction Damper Operator: Pneumatic, spring range matching reset range of controller.
  - d. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.
- OR**
- Electronic Controls: Pneumatic damper operators, electronic controller integral airflow transducer, and electronic thermostat. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:
- a. Damper Actuator: Pneumatic, **0- to 13-psig (0- to 90-kPa)** spring range.
  - b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to **4-inch wg (1000 Pa)**; and shall have a multipoint velocity sensor at air inlet.
  - c. Induction Damper Operator: Pneumatic, spring range matching reset range of controller.
  - d. Thermostat: Wall-mounted electronic type with the following features:
    - 1) Proportional, plus integral control of room temperature.
    - 2) Time-proportional reheat-coil control.
    - 3) Temperature set-point display in Fahrenheit and Celsius.

F. Shutoff, Single-Duct Air Terminal Units

1. Configuration: Volume-damper assembly inside unit casing with control components inside a protective metal shroud.
2. Casing: **0.034-inch (0.85-mm)** steel **OR** **0.032-inch (0.8-mm)** aluminum, **as directed**, single **OR** double, **as directed**, wall.
  - a. Casing Lining: Adhesive attached, **1/2-inch- (13-mm-)** **OR** **3/4-inch- (19-mm-)** **OR** **1-inch- (25-mm-)**, **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    - 1) Cover liner with nonporous foil.
    - OR**  
Cover liner with nonporous foil and perforated metal.
  - OR**  
Casing Lining: Adhesive attached, **1/2-inch- (13-mm-)** **OR** **3/4-inch- (19-mm-)** **OR** **1-inch- (25-mm-)**, **as directed**, thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
  - b. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
  - c. Air Outlet: S-slip and drive connections, size matching inlet size, **as directed**.
  - d. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
  - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Regulator Assembly: System-air-powered bellows section incorporating polypropylene bellows for volume regulation and thermostatic control. Bellows shall operate at temperatures from **0 to 140 deg F (minus 18 to plus 60 deg C)**, shall be impervious to moisture and fungus, shall be suitable for **10-inch wg (2500-Pa)** static pressure, and shall be factory tested for leaks.
4. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
  - a. Maximum Damper Leakage: ARI 880 rated, **2 OR 3**, **as directed**, percent of nominal airflow at **3-inch wg (750-Pa)** **OR** **6-inch wg (1500-Pa)**, **as directed**, inlet static pressure.
  - b. Damper Position: Normally open **OR** closed, **as directed**.
5. Attenuator Section: **0.034-inch (0.85-mm)** steel **OR** **0.032-inch (0.8-mm)** aluminum, **as directed**, sheet.
  - a. Lining: Adhesive attached, **1/2-inch- (13-mm-)** **OR** **3/4-inch- (19-mm-)** **OR** **1-inch- (25-mm-)**, **as directed**, thick, coated, fibrous-glass duct liner complying with ASTM C 1071, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
    - 1) Cover liner with nonporous foil.
    - OR**  
Cover liner with nonporous foil and perforated metal.
  - OR**  
Lining: Adhesive attached, **3/4-inch- (19-mm-)** thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
  - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
6. Multioutlet Attenuator Section: With two **OR** three **OR** four, **as directed**, **6-inch- (150-mm-)** **OR** **8-inch- (200-mm-)** **OR** **10-inch- (250-mm-)**, **as directed**, diameter collars, each with locking butterfly balancing damper.
7. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and rated for a minimum working pressure of **200 psig (1380 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain valve.

**OR**



Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware.

- a. Access door interlocked disconnect switch.
  - b. Downstream air temperature sensor with local connection to override discharge-air temperature to not exceed a maximum temperature set point (adjustable.)
  - c. Nickel chrome 80/20 heating elements.
  - d. Airflow switch for proof of airflow.
  - e. Fan interlock contacts.
  - f. Fuses in terminal box for overcurrent protection (for coils more than 48 A).
  - g. Mercury contactors.
  - h. Pneumatic-electric switches and relays.
  - i. Magnetic contactor for each step of control (for three-phase coils).
8. Electric Controls: Damper actuator and thermostat.
- a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
  - b. Thermostat: Wall-mounted electronic type with clock display, temperature display in Fahrenheit and Celsius, and space temperature set point.

**OR**

Pneumatic Controls: Damper operator and velocity controller. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Pneumatic Damper Operator: **0- to 13-psig (0- to 90-kPa)** spring range.
- b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to **4-inch wg (1000 Pa)**; and shall have a multipoint velocity sensor at air inlet.
- c. Thermostat: Wall-mounted pneumatic type with appropriate mounting hardware.

**OR**

Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
- b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to **4-inch wg (1000 Pa)**; and shall have a multipoint velocity sensor at air inlet.
- c. Thermostat: Wall-mounted electronic type with temperature set-point display in Fahrenheit and Celsius.

**OR**

Direct Digital Controls: Single-package unitary controller and actuator specified in Division 23 Section "Instrumentation And Control For Hvac".

**OR**

Direct Digital Controls: Bidirectional damper operators and microprocessor-based controller and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:

- a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
- b. Terminal Unit Controller: Pressure-independent, variable-air-volume controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
  - 1) Occupied and unoccupied operating mode.

- 2) Remote reset of airflow or temperature set points.
- 3) Adjusting and monitoring with portable terminal.
- 4) Communication with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
- c. Room Sensor: Wall mounted with temperature set-point adjustment and access for connection of portable operator terminal.
9. Control Sequence:
  - a. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg (60- and 750-Pa) inlet static pressure.
  - b. System-powered, wall-mounted thermostat.
- G. Diffuser-Type Air Terminal Units
  1. Configuration: Volume-damper, diffuser, controller assembly and electric heater, **as directed**, and wall-mounted thermostat with master-slave capability, **as directed**.
  2. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
    - a. Damper Position: Normally open **OR** closed, **as directed**.
  3. Diffuser: Galvanized steel with white baked-enamel finish.
  4. Electronic Controls: Bidirectional damper operator and microprocessor-based thermostat with integral airflow transducer and room sensor. Control devices shall be compatible with temperature controls specified in Division 23 Section "Instrumentation And Control For Hvac" and shall have the following features:
    - a. Damper Actuator: 24 V, powered closed, spring return open **OR** powered open, **as directed**.
    - b. Velocity Controller: Factory calibrated and field adjustable to minimum and maximum air volumes; shall maintain constant airflow dictated by thermostat within 5 percent of set point while compensating for inlet static-pressure variations up to 4-inch wg (1000 Pa); and shall have a multipoint velocity sensor at air inlet.
    - c. Thermostat: Wall-mounted electronic type with the following features:
      - 1) Proportional, plus integral control of room temperature.
      - 2) Temperature set-point display in Fahrenheit and Celsius.
  5. Integral thermally powered actuators control diffusion dampers based on duct and room temperature.
- H. Hangers And Supports
  1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
  2. Hanger Rods for Corrosive Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.
  3. Steel Cables: Galvanized steel complying with ASTM A 603 **OR** Stainless steel complying with ASTM A 492, **as directed**.
  4. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.
  5. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
  6. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.
- I. Seismic-Restraint Devices
  1. General Requirements for Restraint Components: Rated strengths, features, and applications shall be as defined in reports by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
    - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
  2. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment to

braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

3. Restraint Cables: ASTM A 603, galvanized **OR** ASTM A 492, stainless, **as directed**, -steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; with an automatic-locking and clamping device or double-cable clips.
4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod.
5. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

J. Source Quality Control

1. Factory Tests, as directed: Test factory-assembled air terminal units according to ARI 880.
  - a. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, coil type, **as directed**, and ARI certification seal.

### 1.3 EXECUTION

A. Installation

1. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
2. Install air terminal units level and plumb. Maintain sufficient clearance for normal service and maintenance.
3. Install wall-mounted thermostats.

B. Hanger And Support Installation

1. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
2. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
  - a. Where practical, install concrete inserts before placing concrete.
  - b. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
  - c. Use powder-actuated concrete fasteners for standard-weight aggregate concretes and for slabs more than 4 inches (100 mm) thick.
  - d. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes and for slabs less than 4 inches (100 mm) thick.
  - e. Do not use powder-actuated concrete fasteners for seismic restraints.
3. Hangers Exposed to View: Threaded rod and angle or channel supports.
4. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

C. Seismic-Restraint-Device Installation

1. Install hangers and braces designed to support the air terminal units and to restrain against seismic forces required by applicable building codes. Comply with SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems" **OR** ASCE/SEI 7, **as directed**.
2. Select seismic-restraint devices with capacities adequate to carry present and future static and seismic loads.
3. Install cables so they do not bend across edges of adjacent equipment or building structure.
4. Install cable restraints on air terminal units that are suspended with vibration isolators.
5. Install seismic-restraint devices using methods approved by an evaluation service member of the ICC Evaluation Service **OR** the Office of Statewide Health Planning and Development for the State of California **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
6. Attachment to Structure: If specific attachment is not indicated, anchor bracing and restraints to structure, to flanges of beams, to upper truss chords of bar joists, or to concrete members.

7. Drilling for and Setting Anchors:
  8. Identify position of reinforcing steel and other embedded items before drilling holes for anchors. Do not damage existing reinforcement or embedded items during drilling. Notify the Owner if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
  9. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
  10. Wedge Anchors: Protect threads from damage during anchor installation. Install heavy-duty sleeve anchors with sleeve fully engaged in the structural element to which anchor is to be fastened.
  11. Set anchors to manufacturer's recommended torque, using a torque wrench.
  12. Install zinc-coated steel anchors for interior applications and stainless-steel anchors for applications exposed to weather.
- D. Connections
1. Install piping adjacent to air terminal unit to allow service and maintenance.
  2. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping", connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
  3. Connect ducts to air terminal units according to Division 23 Section(s) "Metal Ducts" OR "Nonmetal Ducts", **as directed**.
  4. Make connections to air terminal units with flexible connectors complying with requirements in Division 23 Section "Air Duct Accessories".
- E. Identification
1. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Division 23 Section "Identification For Hvac Piping And Equipment" for equipment labels and warning signs and labels.
- F. Field Quality Control
1. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  2. Tests and Inspections:
    - a. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
    - b. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
    - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  3. Air terminal unit will be considered defective if it does not pass tests and inspections.
  4. Prepare test and inspection reports.
- G. Startup Service
1. Perform startup service.
    - a. Complete installation and startup checks according to manufacturer's written instructions.
    - b. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
    - c. Verify that controls and control enclosure are accessible.
    - d. Verify that control connections are complete.
    - e. Verify that nameplate and identification tag are visible.
    - f. Verify that controls respond to inputs as specified.

H. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 23 36 16 00

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Task	Specification	Specification Description
23 37 13 13	23 31 13 19	Duct Accessories
23 37 13 13	23 36 13 00	Diffusers, Registers, And Grilles
23 37 13 43	23 31 13 19	Duct Accessories
23 37 13 43	23 36 13 00	Diffusers, Registers, And Grilles
23 37 23 13	07 72 13 00a	Intake and Relief Ventilators
23 38 13 16	01 22 16 00	No Specification Required
23 38 13 16	11 21 63 00	Food Service Equipment
23 38 13 16	23 31 13 13	Metal Ducts
23 38 13 16	07 72 13 00a	Intake and Relief Ventilators

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## SECTION 23 41 13 00 - AIR FILTERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for particulate air infiltration. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Metal panel filters.
  - b. Flat panel filters.
  - c. Pleated panel filters.
  - d. Ring panel filters.
  - e. Nonsupported bag filters.
  - f. Supported bag filters.
  - g. Rigid cell box filters.
  - h. V-bank cell filters.
  - i. Self-supported pocket filters.
  - j. Automatic roll filters.
  - k. Bulk media.
  - l. Front- and rear-access filter frames.
  - m. Side-service housings.
  - n. Filter gages.

#### C. Submittals

1. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
2. LEED Submittals:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
  - b. Product Data for Credit EQ 4.1: For adhesives and sealants, including printed statement of VOC content.
3. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
  - a. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
  - b. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
  - c. Wiring Diagrams: For power, signal, and control wiring.
4. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
  - a. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."



- b. Comply with ASHRAE 52.1 for arrestance and ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
  - 3. Comply with NFPA 90A and NFPA 90B.

E. Coordination

- 1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.

## 1.2 PRODUCTS

### A. Metal Panel Filters

- 1. Description: Factory-fabricated, self-supported, cleanable, all-metal, impingement-type, panel-type, permanent air filters with holding frames.
- 2. Media: Four **OR** Six, **as directed**, alternate layers of galvanized-steel **OR** aluminum **OR** stainless-steel, **as directed**, flat and herringbone-crimp screen.
  - a. Nonoiled for grease removal application.
  - b. Adhesive coating.
    - 1) Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- 3. Filter-Media Frame: Galvanized steel **OR** Hot-dip galvanized steel **OR** Aluminum **OR** Stainless steel, **as directed**, hinged, and with pull and retaining handles fastened to the media.
  - a. Drain holes.

### B. Flat Panel Filters

- 1. Description: Factory-fabricated, self-supported, flat, nonpleated, panel-type, disposable air filters with holding frames.
- 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
- 3. Media: Interlaced glass or synthetic fibers **OR** Cotton and synthetic fibers, **as directed**, coated with nonflammable adhesive.
  - a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - b. Media shall be coated with an antimicrobial agent.
  - c. Metal Retainer: Upstream side and downstream side.
- 4. Filter-Media Frame: Cardboard with perforated metal retainer **OR** Galvanized steel with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles, **as directed**, sealed or bonded to the media.
- 5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.

### C. Pleated Panel Filters

- 1. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
- 2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
- 3. Media: Interlaced glass or synthetic fibers **OR** Cotton and synthetic fibers, **as directed**, coated with nonflammable adhesive.
  - a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - b. Media shall be coated with an antimicrobial agent.
  - c. Separators shall be bonded to the media to maintain pleat configuration.
  - d. Welded wire grid shall be on downstream side to maintain pleat.
  - e. Media shall be bonded to frame to prevent air bypass.
  - f. Support members on upstream and downstream sides to maintain pleat spacing.
- 4. Filter-Media Frame: Cardboard frame with perforated metal retainer **OR** Galvanized steel **OR** Aluminized steel, **as directed**, with metal grid on outlet side and steel rod grid on inlet side, hinged, with pull and retaining handles, **as directed**, sealed or bonded to the media.

5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- D. Ring Panel Filters
1. Description: Internally supported, flat panel filters for installation in a filter track.
  2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
  3. Media: Two **OR** Three **OR** Four, **as directed**, -ply polyester with sealed edges.
    - a. Panel Construction: Single with one edge unsealed for support removal, **as directed**, **OR** Linked, **as directed**.
    - b. Media shall be coated with an antimicrobial agent.
  4. Internal Support: 9-gage steel wire frame.
- E. Nonsupported Bag Filters
1. Description: Factory-fabricated, dry, extended-surface, nonsupported filters with header frames.
  2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
  3. Media: Glass-fiber **OR** Synthetic, **as directed**, material constructed so individual pockets are maintained in tapered form under rated-airflow conditions by flexible internal supports.
    - a. Media shall be coated with an antimicrobial agent.
  4. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
  5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- F. Supported Bag Filters
1. Description: Factory-fabricated, dry, extended-surface, self-supported filters with holding frames in steel, basket-type retainers.
  2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
  3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
    - a. Media shall be coated with an antimicrobial agent.
  4. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
  5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- G. Rigid Cell Box Filters
1. Description: Factory-fabricated, adhesive-coated, **as directed**, disposable, packaged air filters with media perpendicular to airflow, and with holding frames.
  2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
  3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
    - a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - b. Media shall be coated with an antimicrobial agent.
  4. Filter-Media Frames: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
  5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- H. V-Bank Cell Filters
1. Description: Factory-fabricated, adhesive-coated, **as directed**, disposable, packaged air filters with media angled to airflow, and with holding frames.
  2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
  3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
    - a. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - b. Media shall be coated with an antimicrobial agent.
  4. Filter-Media Frames: Galvanized steel **OR** Hard polyurethane foam, **as directed**.

5. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- I. Self-Supported Pocket Filters
1. Description: Factory-fabricated, panel-type, disposable air filters with contoured media for extended surface.
  2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
  3. Media: Fibrous material constructed so individual pleats are maintained in tapered form under rated-airflow conditions by flexible internal supports.
    - a. Media shall be coated with an antimicrobial agent.
  4. Configuration: Single-pocket cube **OR** Multipocket, **as directed**.
  5. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
  6. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- J. Automatic Roll Filters
1. Description: Factory-fabricated, automatic, motor-driven, roll-type filters with holding casing.
  2. Arrangement: Horizontal **OR** Vertical, **as directed**.
  3. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
  4. Media: Compressed and rolled, fibrous-glass material; viscous coated.
    - a. Media shall be coated with an antimicrobial agent.
  5. Holding Frame: Galvanized steel with enclosed, clean media roll arranged to allow upstream replacement of filter media.
    - a. Auxiliary Frame: Locate on downstream side of unit with downstream **OR** side, **as directed**, access.
    - b. Final Filter: Extended-surface, retained **OR** nonsupported, **as directed**, media.
  6. Control and Drive: Electric, gear-reducer, motor-driven, feed-control mechanism equipped with manual media advance and runout switches for stopping media movement of filter bank and operating remote warning signal lights.
    - a. Manual Control: Manual switch to advance media, and wired to override automatic controls.
    - b. Automatic Control: Prewired control package to advance media when filter resistance exceeds preselected high limit **OR** after preselected operating time, **as directed**.
- K. Bulk Media
1. Description: Air-filter media, factory custom cut or rolled.
  2. Filter Unit Class: UL 900, Class 1 **OR** Class 2, **as directed**.
  3. Media: Spun glass **OR** Synthetic **OR** Polyester, **as directed**, in a roll **OR** cut into pads, **as directed**.
- L. Front- And Rear-Access Filter Frames
1. Framing System: Galvanized-steel **OR** Aluminum, **as directed**, framing members with access for either upstream (front) or downstream (rear) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
  2. Prefilters: Incorporate a separate track with spring clips, **as directed**, removable from front or back, **as directed**.
  3. Sealing: Factory-installed, positive-sealing device for each row of filters, to ensure seal between gasketed filter elements and to prevent bypass of unfiltered air.
- M. Side-Service Housings
1. Description: Factory-assembled, side-service housings, constructed of galvanized steel **OR** aluminum, **as directed**, with flanges to connect to duct or casing system.
  2. Prefilters: Integral tracks to accommodate **2-inch- (50-mm-)** deep, disposable or washable, **as directed**, filters.

3. Access Doors: Hinged, with continuous **OR** Continuous, **as directed**, gaskets on perimeter and positive-locking devices, and arranged so filter cartridges can be loaded from either access door.
4. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames and to prevent bypass of unfiltered air.

N. Filter Gages

1. Diaphragm-type gage with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
  - a. Diameter: **4-1/2 inches (115 mm) OR 2 inches (50 mm), as directed.**
  - b. Scale Range for Filter Media Having a Recommended Final Resistance of **0.5-Inch wg (125 Pa)** or Less: **0- to 0.5-inch wg (0 to 125 Pa).**
  - c. Scale Range for Filter Media Having a Recommended Final Resistance of **0.5- to 1.0-Inch wg (125 to 250 Pa)** or Less: **0- to 1.0-inch wg (0 to 250 Pa).**
  - d. Scale Range for Filter Media Having a Recommended Final Resistance of **1.0- to 2.0-Inch wg (250 to 500 Pa)** or Less: **0- to 2.0-inch wg (0 to 500 Pa).**
  - e. Scale Range for Filter Media Having a Recommended Final Resistance of **2.0- to 3.0-Inch wg (500 to 750 Pa)** or Less: **0- to 3.0-inch wg (0 to 750 Pa).**
  - f. Scale Range for Filter Media Having a Recommended Final Resistance of **3.0- to 4.0-Inch wg (750 to 1000 Pa)** or Less: **0- to 4.0-inch wg (0 to 1000 Pa).**
2. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale and logarithmic-curve tube gage with integral leveling gage, graduated to read from **0- to 3.0-inch wg (0 to 750 Pa)**, and accurate within 3 percent of the full scale range.
3. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

1.3 EXECUTION

A. Installation

1. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
2. Install filters in position to prevent passage of unfiltered air.
3. Install filter gage for each filter bank.
4. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
5. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream from filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
6. Coordinate filter installations with duct and air-handling-unit installations.

B. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
  - a. Operate automatic roll filters to demonstrate compliance with requirements.
  - b. Test for leakage of unfiltered air while system is operating.
3. Air filter will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

C. Cleaning

1. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

END OF SECTION 23 41 13 00

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## SECTION 23 41 13 00a - GAS-PHASE AIR FILTRATION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for gas-phase air infiltration. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Activated-carbon panel filters.
  - b. Activated-carbon, deep-V filters.
  - c. Activated carbon, V-cell filters.
  - d. Cylindrical-canister filters.
  - e. Permanganate filters.
  - f. Supported adsorber bag filters.
  - g. Front-access filter housings.
  - h. Side-service housings.
  - i. Filter gages.

#### C. Submittals

1. Product Data: For each type of product indicated. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.
2. LEED Submittal:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment."
3. Shop Drawings: For air filters. Include plans, elevations, sections, details, and attachments to other work.
  - a. Show filter rack assembly, dimensions, materials, and methods of assembly of components.
  - b. Include setting drawings, templates, and requirements for installing anchor bolts and anchorages.
4. Field quality-control reports.
5. Operation and Maintenance Data: For each type of filter and rack to include in emergency, operation, and maintenance manuals.

#### D. Quality Assurance

1. ASHRAE Compliance:
  - a. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Comply with NFPA 90A and NFPA 90B.

### 1.2 PRODUCTS

#### A. Activated-Carbon Panel Filters

1. Description: Factory-fabricated unit with activated-carbon media.
2. Media: Flat-panel, disposable multilayer filter with an inlet layer of polyester fibers, a layer of activated-carbon granules bonded to fibers, and a layer of polyurethane foam; housed in a cardboard frame.



3. Media: Flat-panel, disposable honeycombed cellulose with cells filled with activated-carbon granules and a perforated mesh grid; housed in a cardboard frame.
4. Media: Pleated, multilayer filter with an inlet layer of cotton and synthetic fibers and a layer of activated-carbon granules bonded to synthetic fibers; media formed into deep-V-shaped pleats, held by self-wire grid, and housed in a cardboard frame.
5. Mounting Frames: Welded, galvanized, sheet-steel frame and galvanized-steel fasteners with polyurethane, **as directed**, gaskets; capable of bolting together into built-up filter banks.

B. Activated-Carbon, Deep-V Filters

1. Description: Factory-fabricated unit with activated-carbon trays in deep-V arrangement with disposable panel prefilter, **as directed**, and final filter, **as directed**.
2. Module Housing: **0.064-inch- (1.6-mm-)** thick, galvanized steel **OR** stainless steel **OR** double-wall casing with **1-inch- (25-mm-)** thick insulation, **as directed**, to hold media-filled panels; with side servicing through gasketed access doors on both sides and able to connect to other housings. Equip housings with metal slide channel tracks to hold activated-carbon trays and particulate prefilter, **as directed**, and final filter, **as directed**.
  - a. Finish: Factory primed **OR** primed and painted, **as directed**, outside **OR** inside and outside **OR** inside, **as directed**.
  - b. Pressure tap and fitting.
3. Media-Holding Panels: **1-inch- (25-mm-)** thick, perforated polystyrene to allow airflow through contained loose-fill media; with removable service cap for recharging.  
**OR**  
Media-Holding Panels: **1 inch (25 mm) OR 2 inches (50 mm) OR 3 inches (75 mm)**, **as directed**, deep and containing granular carbon bonded into a briquette form with a galvanized **OR** stainless, **as directed**, -steel frame.
4. Media: **45 lb (20.3 kg)** per **1000 cfm (470 L/s)** of loose-fill **OR** loose-fill or bonded-briquette **OR** bonded-briquette, **as directed**, coconut-shell activated carbon.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: **32 lb/cu. ft. (510 kg/cu. m)**.
  - d. Mesh Size: **4 by 6 inches (100 by 150 mm)**, 90 percent minimum.
  - e. Hardness Factor: 95 when tested according to ASTM D 3802.
5. Media: loose-fill **OR** loose-fill or bonded-briquette **OR** bonded-briquette, **as directed**, activated alumina impregnated with potassium permanganate.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: **32 lb/cu. ft. (510 kg/cu. m)**.
  - d. Mesh Size: **4 by 6 inches (100 by 150 mm)**, 90 percent minimum.
  - e. Hardness Factor: 95 when tested according to ASTM D 3802.
6. Media: loose-fill **OR** loose-fill or bonded-briquette **OR** bonded-briquette, **as directed**, impregnated carbon.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: **32 lb/cu. ft. (510 kg/cu. m)**.
  - d. Mesh Size: **4 by 6 inches (100 by 150 mm)**, 90 percent minimum.
  - e. Hardness Factor: 95 when tested according to ASTM D 3802.
7. Media: loose-fill **OR** loose-fill or bonded-briquette **OR** bonded-briquette, **as directed**, blended carbon and alumina impregnated with potassium permanganate.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: **32 lb/cu. ft. (510 kg/cu. m)**.

- d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
- e. Hardness Factor: 95 when tested according to ASTM D 3802.

C. Activated-Carbon, V-Cell Filters

- 1. Description: Factory-fabricated, dry, V-shaped cartridges containing loose-fill media with holding frames.
- 2. Cartridges: V-cell configuration, plastic enclosure caps, galvanized-steel frame with vertical galvanized-steel channel supports. Integral, 1-inch- (25-mm-) deep panels constructed of honeycombed paper and nylon mesh.
- 3. Fill Media: Coconut-shell activated carbon; 45 lb (20.3 kg) of activated carbon per 1000 cfm (470 L/s) of airflow.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
  - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
  - e. Hardness Factor: 95 when tested according to ASTM D 3802.
- 4. Fill Media: Activated alumina impregnated with potassium permanganate; 10.5 lb (4.8 kg) of adsorbent per 500 cfm (236 L/s) of airflow.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
  - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
  - e. Hardness Factor: 95 when tested according to ASTM D 3802.
- 5. Fill Media: Impregnated carbon; 8.0 lb (3.6 kg) of adsorbent per 500 cfm (236 L/s) of airflow.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
  - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
  - e. Hardness Factor: 95 when tested according to ASTM D 3802.
- 6. Fill Media: Blended carbon and alumina impregnated with potassium permanganate; 7.0 lb (3.1 kg) of adsorbent per 500 cfm (236 L/s) of airflow.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).
  - d. Mesh Size: 4 by 6 inches (100 by 150 mm), 90 percent minimum.
  - e. Hardness Factor: 95 when tested according to ASTM D 3802.
- 7. Mounting Frames: Welded, galvanized, sheet-steel frame and galvanized-steel fasteners with gaskets; capable of bolting together into built-up filter banks.

D. Cylindrical-Canister Filters

- 1. Description: Factory-fabricated, dry, cylindrical canisters containing loose-fill adsorbent with holding frames.
- 2. Cylinders: 0.0455-inch- (1.2-mm-) thick, perforated, electroplated **OR** stainless, **as directed**, steel, with end plate.
- 3. Fill Media: 5.0 lb (2.3 kg) **OR** 6.7 lb (3.0 kg), **as directed**, of coconut-shell activated carbon **OR** activated alumina impregnated with potassium permanganate **OR** impregnated carbon **OR** blended carbon and alumina impregnated with potassium permanganate, **as directed**, per canister.
  - a. Ash Content: 2 to 3 percent.
  - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
  - c. Bulk Density: 32 lb/cu. ft. (510 kg/cu. m).



- d. Mesh Size: **4 by 6 inches (100 by 150 mm)**, 90 percent minimum.
  - e. Hardness Factor: 95 when tested according to ASTM D 3802.
  4. Mounting Frames: Welded galvanized, sheet steel with galvanized-steel fasteners **OR** stainless steel with stainless-steel fasteners, **as directed**, with gaskets; designed for bolting together into built-up filter banks.
- E. Permanganate Filters
1. Description: Factory-fabricated modules containing loose-fill adsorbent with holding frames.
  2. Modules: Permanent type, **24 inches wide by 24 inches high by 24 inches deep (600 mm wide by 600 mm high by 600 mm deep)**; shall hold both potassium permanganate and activated carbon. Manufactured in two pieces, each **12 inches (300 mm)** wide for ease of installation.
  3. Media: Porous spherical pellets formed from a combination of powdered, activated carbon and other binders, impregnated with potassium permanganate.
    - a. Leach Test: 180 minutes.
    - b. Potassium Permanganate Content: 4 percent minimum.
    - c. Moisture Content: 20 percent maximum.
    - d. Bulk Density: **34 lb/cu. ft. (0.54 g/mL) OR 50 lb/cu. ft. (0.8 g/mL), as directed.**
    - e. Crush Strength: **40 OR 50 OR 60, as directed**, percent maximum.
    - f. Abrasion: 4 percent maximum.
    - g. Nominal Pellet Diameter: **0.125 inch (3.175 mm)**.
    - h. Percent of Pellet Sizes: 80 to 85 percent after screening.
  4. Media: High-grade carbon, manufactured from coconut shells, bituminous coal, or a combination of both.
    - a. Ash Content: 2 to 3 percent.
    - b. Percent Carbon Tetrachloride Activity: 35 to 70 percent when tested according to ASTM D 3467.
    - c. Bulk Density: **32 lb/cu. ft. (510 kg/cu. m)**.
    - d. Mesh Size: **4 by 6 inches (100 by 150 mm)**, 90 percent minimum.
    - e. Hardness Factor: 95 when tested according to ASTM D 3802.
  5. Frame: Galvanized steel **OR** Hot-dip galvanized steel **OR** Aluminum **OR** Stainless steel, **as directed**, hinged, and with pull and retaining handles fastened to the media.
- F. Supported Adsorber Bag Filters
1. Description: Factory-fabricated, dry, extended-surface, self-supporting filters with holding frames.
  2. Media: Carbon-filled fibrous material constructed so individual pleats are maintained under rated-airflow conditions in tapered form by flexible internal supports.
  3. Filter-Media Frame: Galvanized steel.
  4. Mounting Frames: Welded, galvanized, sheet-steel frame and galvanized-steel fasteners with gaskets; capable of bolting together into built-up filter banks.
- G. Front-Access Filter Frames
1. Framing System: Galvanized-steel **OR** Aluminum, **as directed**, framing members with access for upstream (front) filter servicing, cut to size and prepunched for assembly into modules. Vertically support filters to prevent deflection of horizontal members without interfering with either filter installation or operation.
  2. Prefilters: Incorporate a separate track with spring clips, **as directed**, removable from front or back, **as directed**.
  3. Sealing: Factory-installed, positive-sealing device for each row of filters to ensure seal between gasketed filter elements to prevent bypass of unfiltered air.
- H. Side-Service Housings
1. Description: Factory-assembled, side-service housings constructed of galvanized steel **OR** aluminum, **as directed**, with flanges to connect to duct or casing system.
  2. Prefilters: Integral tracks to accommodate **2-inch- (50-mm-)** thick, disposable or washable, **as directed**, filters.

3. Access Doors: Hinged with continuous **OR** Continuous, **as directed**, gaskets on perimeter and with positive-locking devices. Arrange so filter cartridges can be loaded from either access door.
4. Sealing: Incorporate positive-sealing gasket material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.

I. Filter Gages

1. Diaphragm type, with dial and pointer in metal case, vent valves, black figures on white background, and front recalibration adjustment.
  - a. Diameter: **4-1/2 inches (115 mm) OR 2 inches (50 mm), as directed**.
  - b. Scale Range for Filter Media Having a Recommended Final Resistance of **0.5-Inch wg (125 Pa)** or Less: **0- to 0.5-inch wg (0 to 125 Pa)**.
  - c. Scale Range for Filter Media Having a Recommended Final Resistance of **0.5- to 1.0-Inch wg (125 to 250 Pa)** or Less: **0- to 1.0-inch wg (0 to 250 Pa)**.
  - d. Scale Range for Filter Media Having a Recommended Final Resistance of **1.0- to 2.0-Inch wg (250 to 500 Pa)** or Less: **0- to 2.0-inch wg (0 to 500 Pa)**.
  - e. Scale Range for Filter Media Having a Recommended Final Resistance of **2.0- to 3.0-Inch wg (500 to 750 Pa)** or Less: **0- to 3.0-inch wg (0 to 750 Pa)**.
  - f. Scale Range for Filter Media Having a Recommended Final Resistance of **3.0- to 4.0-Inch wg (750 to 1000 Pa)** or Less: **0- to 4.0-inch wg (0 to 1000 Pa)**.
2. Manometer-Type Filter Gage: Molded plastic, with epoxy-coated aluminum scale, logarithmic-curve tube gage with integral leveling gage; graduated to read from **0- to 3.0-inch wg (0 to 750 Pa)** and accurate within 3 percent of full-scale range.
3. Accessories: Static-pressure tips, tubing, gage connections, and mounting bracket.

1.3 EXECUTION

A. Installation

1. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
2. Install filters in position to prevent passage of unfiltered air.
3. Install filter gage for each filter bank.
4. Do not operate fan system until particulate filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing with new, clean filters.
5. Do not install gas-phase filters until fan system is clean and there is no risk of construction debris loading the filter.
6. Install filter-gage, static-pressure taps upstream and downstream from filters. Install filter gages on filter banks with separate static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in an accessible position. Adjust and level inclined gages.
7. Coordinate filter installations with duct and air-handling unit installations.

B. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
  - a. Test for leakage of unfiltered air while system is operating.
3. Air filter will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

C. Cleaning

1. After completing system installation and testing, adjusting, and balancing air-handling and air-distribution systems, clean filter housings and install new particulate filter media.

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Task	Specification	Specification Description
23 41 13 00	22 11 19 00	Electronic Air Cleaners
23 41 16 00	23 41 13 00	Air Filters
23 41 16 00	22 11 19 00	Electronic Air Cleaners
23 41 19 00	23 41 13 00	Air Filters
23 41 19 00	22 11 19 00	Electronic Air Cleaners
23 41 33 00	23 41 13 00	Air Filters
23 41 33 00	22 13 19 00	High-Efficiency Particulate Filtration
23 42 13 00	23 41 13 00	Air Filters
23 42 13 00	23 41 13 00a	Gas-Phase Air Filtration

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## SECTION 23 51 13 13 - BREECHINGS, CHIMNEYS, AND STACKS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for breechings, chimneys, and stacks. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Listed chimney liners.
  - b. Listed single-wall and double-wall vents and chimneys.
  - c. Listed, refractory-lined breechings and stacks.
  - d. Field-fabricated metal breechings and chimneys.
  - e. Listed grease and dishwasher ducts.

#### C. Submittals

1. Product Data: For the following:
  - a. Chimney liners.
  - b. Type B and BW vents.
  - c. Type L vents.
  - d. Special gas vents.
  - e. Building-heating-appliance chimneys.
  - f. Grease ducts.
  - g. Refractory-lined metal breechings and chimneys.
  - h. Guy wires and connectors.
2. Shop Drawings: For vents, breechings, chimneys, and stacks. Include plans, elevations, sections, details, and attachments to other work.
3. Welding certificates.
4. Manufacturer Seismic Qualification Certification: Submit certification that factory-fabricated breeching, chimneys, and stacks; accessories; and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Warranty: Warranty specified in this Section.

#### D. Quality Assurance

1. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code--Steel," for hangers and supports and AWS D9.1/D9.1M, "Sheet Metal Welding Code," for shop and field welding of joints and seams in vents, breechings, and stacks.

#### E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of venting system that fail in materials or workmanship within 10 **OR** 15 **OR** 25, **as directed**, years from date of Final Completion. Failures include, but are not limited to, structural failures caused by expansion and contraction.

### 1.2 PRODUCTS

#### A. Listed Chimney Liners

1. Description: Straight **OR** Corrugated, **as directed**, single-wall chimney liner tested according to UL 1777 and rated for **1000 deg F (538 deg C)** continuously, or **2100 deg F (1150 deg C)** for 10 minutes; with negative or positive flue pressure complying with NFPA 211.

2. Straight Liner Materials: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
  3. Corrugated Liner Materials: ASTM A 240/A 240M, Type 321 **OR** ASTM A 240/A 240M, Type 430 **OR** ASTM A 959, Type 29-4C, **as directed**, stainless steel.
  4. Accessories:
    - a. Fittings: Tees, elbows, increasers, draft-hood connectors, metal caps with bird barriers, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar or compatible materials and designs.
    - b. Sealant: Manufacturer's standard high-temperature sealant.
    - c. Insulating Fill: Manufacturer's standard high-temperature insulation fill material in annular space surrounding chimney liner including high-temperature, ceramic-fiber insulation required to seal chimney at top and bottom.
- B. Listed Type B And BW Vents
1. Description: Double-wall metal vents tested according to UL 441 and rated for **480 deg F (248 deg C)** continuously for Type B, or **550 deg F (288 deg C)** continuously for Type BW; with neutral or negative flue pressure complying with NFPA 211.
  2. Construction: Inner shell and outer jacket separated by at least a **1/4-inch (6-mm)** airspace.
  3. Inner Shell: **ASTM B 209 (ASTM B 209M)**, Type 1100 aluminum **OR** **ASTM B 209 (ASTM B 209M)**, Type 3003 aluminum **OR** **ASTM B 209 (ASTM B 209M)**, Type 3105 aluminum **OR** ASTM A 666, Type 430 stainless steel, **as directed**.
  4. Outer Jacket: Galvanized **OR** Aluminized, **as directed**, steel.
  5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
    - a. Termination:
      - 1) Stack cap designed to exclude minimum 90 percent of rainfall.  
**OR**  
Round chimney top designed to exclude minimum 98 percent of rainfall.  
**OR**  
Exit cone with drain section incorporated into riser.  
**OR**  
Antibackdraft.
- C. Listed Type L Vents
1. Description: Double-wall metal vents tested according to UL 641 and rated for **570 deg F (300 deg C)** continuously, or **1700 deg F (926 deg C)** for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
  2. Construction: Inner shell and outer jacket separated by at least a **1/4-inch (6-mm) OR 1-inch (25-mm) OR 2-inch (50-mm) OR 4-inch (100-mm)**, **as directed**, airspace filled with high-temperature, ceramic-fiber **OR** mineral-wool, **as directed**, insulation.
  3. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
  4. Outer Jacket: Galvanized **OR** Aluminized **OR** Stainless, **as directed**, steel.
  5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
    - a. Termination:
      - 1) Stack cap designed to exclude 90 percent of rainfall.  
**OR**  
Round chimney top designed to exclude 98 percent of rainfall.  
**OR**  
Exit cone with drain section incorporated into riser.
- D. Listed Special Gas Vents
1. Description: Double-wall metal vents tested according to UL 1738 and rated for **480 deg F (248 deg C)** continuously, with positive or negative flue pressure complying with NFPA 211.

2. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (13-mm) airspace.
  3. Inner Shell: ASTM A 959, Type 29-4C stainless steel.
  4. Outer Jacket: Aluminized **OR** Stainless, **as directed**, steel.
  5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
    - a. Termination:
      - 1) Stack cap designed to exclude minimum 90 percent of rainfall.  
**OR**  
Round chimney top designed to exclude minimum 98 percent of rainfall.  
**OR**  
Exit cone with drain section incorporated into riser.
- E. Listed Building-Heating-Appliance Chimneys
1. Description for building-heating-appliance chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously, or 1700 deg F (926 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
    - a. Construction: Inner shell and outer jacket separated by at least a 1/2-inch (25-mm) **OR** 1-inch (50-mm) **OR** 2-inch (50-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation, **as directed**.
    - b. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
  2. Description for 1400 deg F (760 deg C) chimneys suitable for dual-fuel boilers, oven vents, water heaters, or exhaust for engines: Double-wall metal vents tested according to UL 103 and UL 959 and rated for 1400 deg F (760 deg C) continuously, or 1800 deg F (982 deg C) for 10 minutes; with positive or negative flue pressure complying with NFPA 211.
    - a. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) **OR** 2-inch (50-mm) **OR** 3-inch (75-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
    - b. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
  3. Description for Type HT chimneys suitable for fireplaces and other solid-fuel-burning appliances: Double-wall metal vents tested according to UL 103 and rated for 1000 deg F (538 deg C) continuously, or 2100 deg F (1150 deg C) for 10 minutes; with neutral or negative flue pressure complying with NFPA 211.
    - a. Construction: Inner shell and outer jacket separated by at least a 1-inch (25-mm) **OR** 1-1/2-inch (38-mm) **OR** 2-inch (50-mm) **OR** 4-inch (100-mm), **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
    - b. Inner Shell: ASTM A 666, Type 304 **OR** ASTM A 666, Type 316 **OR** ASTM A 240/A 240M, Type 430, **as directed**, stainless steel.
  4. Outer Jacket: Galvanized **OR** Aluminized **OR** Stainless, **as directed**, steel.
  5. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
    - a. Termination:
      - 1) Stack cap designed to exclude minimum 90 percent of rainfall.  
**OR**  
Round chimney top designed to exclude minimum 98 percent of rainfall.  
**OR**  
Exit cone with drain section incorporated into riser.
- F. Listed Grease Ducts
1. Description: Double-wall metal vents tested according to UL 1978 and rated for 500 deg F (260 deg C) continuously, or 2000 deg F (1093 deg C) for 30 minutes; with positive or negative duct pressure and complying with NFPA 211.



2. Construction: Inner shell and outer jacket separated by at least a **1-inch (25-mm) OR 2-inch (50-mm) OR 3-inch (75-mm) OR 4-inch (100-mm)**, **as directed**, annular space filled with high-temperature, ceramic-fiber insulation.
  3. Inner Shell: ASTM A 666, Type 304 **OR** Type 316, **as directed**, stainless steel.
  4. Outer Jacket: Aluminized **OR** Stainless, **as directed**, steel where concealed. Stainless steel where exposed.
  5. Accessories: Tees, elbows, increasers, hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly. Include unique components required to comply with NFPA 96 including cleanouts, transitions, adapters and drain fittings.
- G. Listed, Refractory-Lined Metal Breechings And Chimneys
1. Comply with ASME STS-1.
  2. Design Wind Loads: **150 mph (241 km/h), as directed**.
  3. Design for seismic conditions at Project site.
  4. Chimney Outer Jacket: Aluminized **OR** Galvanized, **as directed**, steel with riveted **OR** welded, **as directed**, seams.
  5. Refractory Lining: Tested according to UL 959 for temperature and acid resistance, and bearing the testing laboratory label.
    - a. Temperature Rating: **1800 deg F (982 deg C)** continuously, and **2000 deg F (1093 deg C)** intermittently.
    - b. Acid Extraction: Maximum of 0.2 percent.
    - c. Cold Crushing Strength: Minimum of **3200 psig (22 MPa)**.
    - d. Thickness: Minimum of **2 inches (50 mm)**.
  6. Finish: Factory-applied, high-heat-resistant paint; color as selected.
  7. Base Section: Acid-resistant-coated, cast-iron anchor lugs for securing stack to foundation with anchorage designed by manufacturer, **as directed**.
  8. Reinforced Cleanout Section: Smoke-tight connection, with gasketed and bolt-tightened inspection plate; neck shall be welded to stack section.
  9. T or Y Sections: Smoke-tight connection, with welded joints and refractory lining; finished with smooth transition and with no exposed metal on inside.
  10. Spark Screen: ASTM A 666, Type 316 stainless steel, **0.0625 inch (1.6 mm)** thick, maximum **1/2-by-1/2-inch (13-by-13-mm)** mesh, with ASTM A 666, Type 304 stainless-steel rolled angle and drawband.
  11. Guy Bands: **8-inch- (200-mm-)** wide bands of same material as jacket, with bolted fasteners.
  12. Roof Penetration: Factory-fabricated thimbles, flashings, and counterflashings.
  13. Fabricate sections, fittings, and accessories as individual pieces or in combination lengths for field handling.
  14. Fabricate components with centrifugally cast refractory lining in lengths suitable for connection with drawbands.
  15. Bond refractory to steel jacket with calcium aluminate cement to prevent separation in finished product during shipping, handling, and installation.
  16. Fabricate stacks with anchor lugs; cleanout; T sections; flashings and counterflashings; and provisions for support, expansion, and contraction.
- H. Field-Fabricated Metal Breechings And Chimneys
1. Fabricate freestanding chimneys according to SMACNA's "Guide for Steel Stack Design and Construction."
  2. Fabricate breechings and chimneys from ASTM A 1011/A 1011M hot-rolled steel with continuously welded joints, complying with NFPA 211 for minimum metal thickness.
    - a. Equal to or Less Than **1.069 Sq. Ft. (0.099 Sq. m.)** or **14 Inches (356 mm)** in Diameter: **0.053 inch (1.35 mm)**.
    - b. Up to **1.396 Sq. Ft. (0.129 Sq. m)** or **16 Inches (406 mm)** in Diameter: **0.067 inch (1.7 mm)**.

- c. Up to **1.764 Sq. Ft. (0.164 Sq. m.)** or **18 Inches (457 mm)** in Diameter: **0.093 inch (2.36 mm)**.
  - d. Larger Than Above: **0.123 inch (3.12 mm)**.
3. Fabricate chimneys and vent connectors from galvanized steel, complying with NFPA 211 for minimum metal thickness.
  - a. Equal to or Less Than **6 Inches (152 mm)** in Diameter: **0.019 inch (0.48 mm)**.
  - b. Up to **10 Inches (254 mm)** in Diameter: **0.024 inch (0.61 mm)**.
  - c. Up to **16 Inches (406 mm)** in Diameter: **0.029 inch (0.74 mm)**.
  - d. Larger Than Above: **0.056 inch (1.42 mm)**.
4. Fabricate chimneys and vent connectors from **ASTM B 209 (ASTM B 209M)**, Type 1100 or 3003, aluminum or stainless steel, complying with NFPA 211 for the following minimum metal thicknesses:
  - a. Aluminum: **0.027 inch (0.69 mm)**.
  - b. Stainless Steel: **0.012 inch (0.31 mm)**.
5. Fabricate cleanout doors from compatible material, same thickness as breeching, bolted and gasketed.
6. Fabricate engine exhaust from ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** Schedule 80, **as directed**, pipe; with welded joints and carbon-steel fittings and flanges.
  - a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
  - b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150, including bolts, nuts, and gaskets.
- I. Guying And Bracing Materials
  1. Cable: Three **OR** Four, **as directed**, galvanized, stranded wires of the following thickness:
    - a. Minimum Size: **1/4 inch (6 mm)** in diameter.
    - b. For ID Sizes **4 to 15 Inches (100 to 381 mm)**: **5/16 inch (8 mm)**.
    - c. For ID Sizes **18 to 24 Inches (457 to 610 mm)**: **3/8 inch (9.5 mm)**.
    - d. For ID Sizes **27 to 30 Inches (685 to 762 mm)**: **7/16 inch (11 mm)**.
    - e. For ID Sizes **33 to 36 Inches (838 to 915 mm)**: **1/2 inch (13 mm)**.
    - f. For ID Sizes **39 to 48 Inches (990 to 1220 mm)**: **9/16 inch (14.3 mm)**.
    - g. For ID Sizes **51 to 60 Inches (1295 to 1524 mm)**: **5/8 inch (16 mm)**.
  2. Pipe: Two **OR** Three, **as directed**, galvanized steel, **NPS 1-1/4 (DN 32)**.
  3. Angle Iron: Two **OR** Three, **as directed**, galvanized steel, **2 by 2 by 0.25 inch (50 by 50 by 6 mm)**.

### 1.3 EXECUTION

#### A. Application

1. Listed Chimney Liners: High-efficiency boiler or furnace vents in masonry chimney, dishwasher exhaust, or Type II commercial kitchen hood.
2. Listed Type B and BW Vents: Vents for certified gas appliances.
3. Listed Type L Vents: Vents for low-heat appliances.
4. Listed Special Gas Vents: Condensing gas appliances.
5. Listed Building-Heating-Appliance Chimneys: Dual-fuel boilers, oven vents, water heaters, and exhaust for engines. Fireplaces and other solid-fuel-burning appliances.
6. Listed Grease Ducts: Type I commercial kitchen grease duct.
7. Listed, Refractory-Lined Metal Breechings and Chimneys: Freestanding dual-fuel boiler vents, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.
8. Field-Fabricated Metal Breechings and Chimneys: Dual-fuel boilers, oven vents, water heaters, exhaust for engines, fireplaces, and other solid-fuel-burning appliances.
9. Field-Fabricated Metal Breechings and Chimneys: Steel pipe for use with engine exhaust.

#### B. Installation Of Listed Vents And Chimneys





1. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
2. Seal between sections of positive-pressure vents and grease exhaust ducts according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
3. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
4. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
5. Lap joints in direction of flow.
6. Connect base section to foundation using anchor lugs of size and number recommended by manufacturer.
7. Join sections with acid-resistant joint cement to provide continuous joint and smooth interior finish.
8. Erect stacks plumb to finished tolerance of no more than 1 inch (25 mm) out of plumb from top to bottom.

C. Installation Of Unlisted, Field-Fabricated Breechings And Chimneys

1. Suspend breechings and chimneys independent of their appliance connections.
2. Install, support, and restrain according to seismic requirements.
3. Align breechings at connections, with smooth internal surface and a maximum 1/8-inch (3-mm) misalignment tolerance.
4. Slope breechings down in direction of appliance, with condensate drain connection at lowest point piped to nearest drain.
5. Lap joints in direction of flow.
6. Support breechings and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

D. Cleaning

1. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes.
2. Clean breechings internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.
3. Provide temporary closures at ends of breechings, chimneys, and stacks that are not completed or connected to equipment.

END OF SECTION 23 51 13 13



Task	Specification	Specification Description
23 51 13 16	23 51 13 13	Breechings, Chimneys, And Stacks
23 51 13 19	23 33 13 13	Draft Control Devices
23 51 13 19	23 31 13 19	Duct Accessories
23 51 16 00	23 51 13 13	Breechings, Chimneys, And Stacks

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## SECTION 23 52 13 00 - ELECTRIC BOILERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for electric boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged, factory-fabricated and -assembled electric boilers, trim, and accessories for generating hot water or steam.

#### C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
  - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
    - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
  - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. NFPA Compliance: Design and fabricate boilers to comply with NFPA 70, "National Electrical Code," Article 424, Paragraphs G and H.
4. UL Compliance: Test boilers for compliance with UL 834, "Heating, Water Supply, and Power Boilers--Electric." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

#### E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace pressure vessels of boilers that fail in materials or workmanship within five years from date of Final Completion.

### 1.2 PRODUCTS

#### A. Manufactured Units

1. Description: Factory-fabricated, -assembled, and -tested electric boilers with trim and controls necessary to generate hot water **OR** steam, **as directed**.

2. Pressure Vessel: Carbon-steel **OR** Cast-iron, **as directed**, pressure vessel mounted on structural-steel base.
3. Nozzles: Flanges for water inlet and **OR** steam, **as directed**, outlet and heating element inserts; threaded connections for trim and controls.
4. Insulation: One layer **OR** Two layers, **as directed**, of minimum **1-inch- (25-mm-)** **OR** **2-inch- (50-mm-)**, **as directed**, thick, glass-fiber insulation.
5. Jacket: Galvanized, **as directed**, sheet metal casing with baked-enamel **OR** powder-coated, **as directed**, protective finish and removable panels with snap-in or interlocking closures for access to pressure vessel.
6. Lifting Lugs: Welded to pressure vessel, extending above jacket.
7. Heating Elements: Copper **OR** Incoloy, **as directed**, sheathed, replaceable electric-resistance element, rated 20 kW maximum, with maximum **50 W/sq. in. (7.7 W/sq. cm)** **OR** **75 W/sq. in. (11.5 W/sq. cm)**, **as directed**, over heat-transfer length.
8. Mounting base to secure boiler to concrete base.
  - a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

**B. Trim For Hot-Water Boilers**

1. Include devices sized to comply with ANSI B31.1, "Power Piping" **OR** ANSI B31.9, "Building Services Piping," **as directed**.
2. Aquastat Controllers: Operating auto-reset high limit.
3. Safety Relief Valve: ASME rated.
4. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
6. Dip-tube in water outlet.
7. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end ball valve sized per requirements of authorities having jurisdiction.
8. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of pressure vessel and sealed with fiber gasket.
  - a. Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
  - b. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

**C. Trim For Steam Boilers**

1. Include devices sized to comply with ANSI B31.1, "Power Piping" **OR** ANSI B31.9, "Building Services Piping," **as directed**.
2. Pressure Controllers: Operating auto-reset high limit.
3. Safety Relief Valve:
  - a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
  - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
    - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
4. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage shall have normal operating pressure about 50 percent of full range.
5. Water Column: Minimum **12-inch (300-mm)** glass gage with shutoff cocks.
6. Drain Valves: Minimum **NPS 3/4 (DN 20)** or nozzle size with hose-end connection.

7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
10. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in an upper port of pressure vessel and sealed with fiber gasket.
  - a. Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
  - b. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

D. Controls

1. Boiler operating controls shall include the following devices and features:
  - a. Control transformer.
  - b. Step controller.
  - c. Recycling relay returns controller to off position after power failure.
  - d. Multistage thermostat.
  - e. Control circuit switch.
  - f. Visual indication for each step.
  - g. Supply-voltage indicator.
  - h. Set-Point Adjust: Set points shall be adjustable.
  - i. Operating Level Control: Factory wired and mounted to cycle feedwater pump(s) for makeup water control.
  - j. Sequence of Operation for hot-water boilers: Electric, factory-fabricated and field-installed panel to control element sequence controller to maintain space temperature in response to thermostat with heat anticipator located in heated space.
  - k. Sequence of Operation: Electric, factory-fabricated and field-installed panel to control element sequence controller to reset supply-water temperature inversely with outside-air temperature. At **0 deg F (minus 17 deg C)** outside-air temperature, set supply-water temperature at **200 deg F (93 deg C)**; at **60 deg F (15 deg C)** outside-air temperature, set supply-water temperature at **140 deg F (60 deg C)**.
  - l. Sequence of Operation for steam boilers: Electric, factory-fabricated and field-installed panel to control element sequence controller to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
    - 1) Include automatic, alternating-operation sequence for multiple boilers to provide equal runtime for boilers.
2. Safety Controls: To maintain safe operating conditions, safety controls limit boiler operation.
  - a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops boiler if operating conditions rise above set point or maximum boiler design temperature **OR** pressure, **as directed**.
  - b. Low-Water Cutoff Switch: Electronic **OR** Float and electronic, **as directed**, probe shall prevent boiler operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
  - c. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
3. Building Management System Interface: Factory install hardware and software to enable building management system to monitor, control, and display boiler status and alarms.
  - a. Hardwired Points:
    - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.



- 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
- b. A communication interface with building management system shall enable building management system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building management system.

#### E. Electrical Power

1. Single-Point Field Power Connection: Factory-installed and -wired switches, transformers, and electrical devices necessary shall provide a single-point field power connection to boiler.
  - a. Field power interface shall be to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
  - b. Interlock with door to de-energize power with door open.
2. Electrical Enclosures: NEMA 250, Type 1, **as directed**, enclosure with hinged door and key-locking handle.
3. Install factory wiring outside of an enclosure in a metal, **as directed**, raceway.
4. Comply with NFPA 70.
  - a. Electrical Circuits: 48 A, maximum.
5. Connectors: Mechanical lugs bolted to copper bus bars or distribution blocks with pressure connectors.
6. Fuses: NEMA FU 1, Class J or K5; 60 A, maximum.
7. Contactors: 3-pole magnetic contactors, listed for 500,000 cycles at full load.
8. Factory-wired internal control devices and heating elements.
  - a. Wiring shall be numbered and color coded to match the wiring diagram.

#### F. Source Quality Control

1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
2. Hydrostatic Test: Factory test assembled boiler including hydrostatic test.

### 1.3 EXECUTION

#### A. Boiler Installation

1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31..
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of **0.25 inch (6.35 mm)**, **as directed**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install electrical devices furnished with boiler but not specified to be factory mounted.

#### B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
4. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
5. Install piping from safety relief valves to nearest floor drain.
6. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
7. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

8. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  2. Tests and Inspections:
    - a. Perform installation and startup checks according to manufacturer's written instructions.
    - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
    - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      - 1) Check and adjust initial operating set points and high- and low-limit safety set points of water level and water temperature **OR** steam pressure, **as directed**.
      - 2) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  3. Remove and replace malfunctioning units and retest as specified above.
  4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
- D. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain boilers. Video training sessions, **as directed**.

END OF SECTION 23 52 13 00

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## SECTION 23 52 16 13 - CONDENSING BOILERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for condensing boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, pulse-combustion, fire-tube, water-tube, and water-jacketed condensing boilers, trim, and accessories for generating hot water or steam.

#### C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
  - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
    - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    - 2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
  - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.
8. Other Informational Submittals:
  - a. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."
5. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.



#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of boilers that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Pulse-Combustion Boilers:
    - 1) Heat Exchanger Damaged by Thermal Shock: 10 years from date of Final Completion.
    - 2) Heat-Exchanger Corrosion: Prorated **OR** Nonprorated, **as directed**, for five years from date of Final Completion.
  - b. Warranty Period for Fire-Tube Condensing Boilers:
    - 1) Leakage and Materials: 10 years from date of Final Completion.
    - 2) Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated **OR** Nonprorated for five years from date of Final Completion.
  - c. Warranty Period for Water-Tube Condensing Boilers: 20 years from date of Final Completion.
  - d. Warranty Period for Water-Jacketed Condensing Boilers:
    - 1) Leakage and Materials: Eight years from date of Final Completion.
    - 2) Heat Exchanger Damaged by Thermal Stress and Corrosion: Prorated **OR** Nonprorated, **as directed**, for five years from date of Final Completion.

### 1.2 PRODUCTS

#### A. Manufactured Units: Pulse-Combustion Condensing Boilers.

1. Description: Factory-fabricated, -assembled, and -tested, pulse-combustion condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls.
2. Heat Exchanger: Type 316L, stainless-steel **OR** Carbon-steel, **as directed**, primary and secondary combustion chamber.
3. Pressure Vessel: Carbon steel with welded heads and tube connections.
4. Exhaust Decoupler: Fiberglass composite material in a corrosion-resistant steel box.
5. Burner: Natural **OR** Propane, **as directed**, gas, self-aspirating and self-venting after initial start.
6. Blower: Centrifugal fan to operate only during start of each burner sequence.
  - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
7. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
8. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
9. Casing:
  - a. Jacket: Sheet metal, with snap-in or interlocking closures.
  - b. Control Compartment Enclosure: NEMA 250, Type 1A.
  - c. Finish: Baked-enamel **OR** Powder-coated, **as directed**, protective finish.
  - d. Insulation: Minimum **2-inch- (50-mm-)** thick, mineral-fiber insulation surrounding the heat exchanger.
  - e. Draft Hood: Integral **OR** External, **as directed**.
  - f. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
  - g. Mounting base to secure boiler to concrete base.
    - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

10. Mufflers: Carbon-steel intake muffler and stainless-steel exhaust.
  11. Condensate Trap: Cast-iron body with stainless-steel internal parts.
- B. Manufactured Units: Fire-Tube Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, fire-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
  2. Heat Exchanger: Nonferrous, corrosion-resistant combustion chamber.
  3. Pressure Vessel: Carbon steel with welded heads and tube connections.
  4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft.
  5. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  6. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
  7. Ignition: Spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
  8. Casing:
    - a. Jacket: Sheet metal **OR** Plastic, **as directed**, with snap-in or interlocking closures.
    - b. Control Compartment Enclosures: NEMA 250, Type 1A.
    - c. Finish: Baked-enamel **OR** Powder-coated, **as directed**, protective finish for sheet metal jacket.
    - d. Insulation: Minimum **2-inch- (50-mm-)** thick, mineral-fiber **OR** polyurethane-foam, **as directed**, insulation surrounding the heat exchanger.
    - e. Combustion-Air Connections: Inlet and vent duct collars.
    - f. Mounting base to secure boiler.
      - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- C. Manufactured Units: Water-Tube Condensing Boilers.
1. Description: Factory-fabricated, -assembled, and -tested, water-tube condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; combustion-air intake connections; water supply, return, and condensate drain connections; and controls. Water heating service only.
  2. Heat Exchanger: Finned-copper primary and stainless-steel secondary heat exchangers.
  3. Combustion Chamber: Stainless steel, sealed.
  4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft drawing from gas premixing valve.
  5. Blower: Centrifugal fan to operate during each burner firing sequence and to prepurge and postpurge the combustion chamber.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  6. Gas Train: Combination gas valve with manual shutoff and pressure regulator.
  7. Ignition: Silicone carbide hot-surface ignition that includes flame safety supervision and 100 percent main-valve shutoff.
  8. Integral Circulator: Cast-iron body and stainless-steel impeller sized for minimum flow required in heat exchanger.
  9. Casing:
    - a. Jacket: Sheet metal, with snap-in or interlocking closures.
    - b. Control Compartment Enclosures: NEMA 250, Type 1A.

- c. Finish: Textured epoxy.
  - d. Insulation: Minimum **1-inch- (25-mm-)** **OR** **2-inch- (50-mm-)**, **as directed**, thick, mineral-fiber insulation surrounding the heat exchanger.
  - e. Combustion-Air Connections: Inlet and vent duct collars.
  - f. Mounting base to secure boiler.
    - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- D. Manufactured Units: Water-Jacketed Condensing Boilers.
- 1. Description: Factory-fabricated, -assembled, and -tested, water-jacketed condensing boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket; flue-gas vent; water supply, return, and condensate drain connections; and controls. Water heating service only.
  - 2. Heat Exchanger: Stainless-steel primary and secondary combustion chamber.
  - 3. Pressure Vessel: Carbon steel with welded heads and tube connections where not in contact with combustion or flue gases.
  - 4. Burner: Natural **OR** Propane, **as directed**, gas, forced draft; swing-open front and burner observation port.
  - 5. Blower: Centrifugal fan, forced draft. Include prepurge and postpurge of the combustion chamber.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - 6. Gas Train: Combination gas valve with manual shutoff and pressure regulator. Include 100 percent safety shutoff with electronic flame supervision.
  - 7. Ignition: Electric-spark ignition with 100 percent main-valve shutoff with electronic flame supervision.
  - 8. Casing:
    - a. Jacket: Sheet metal, with snap-in or interlocking closures.
    - b. Control Compartment Enclosures: NEMA 250, Type 1A.
    - c. Finish: Powder-coated protective finish.
    - d. Insulation: Minimum **4-inch- (100-mm-)** thick, mineral-fiber insulation surrounding the heat exchanger.
    - e. Combustion-Air Connections: Inlet and vent duct collars.
    - f. Mounting base to secure boiler.
      - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- E. Trim: For Hot-Water Boilers.
- 1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
  - 2. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
  - 3. Safety Relief Valve: ASME rated.
  - 4. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
  - 5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
  - 6. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end gate valve.

7. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.
- F. Trim: For Steam Boilers.
1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
  2. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
  3. Safety Relief Valve:
    - a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
    - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
      - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
  4. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage shall have normal operating pressure about 50 percent of full range.
  5. Water Column: Minimum **12-inch (300-mm)** glass gage with shutoff cocks.
  6. Drain Valves: Minimum **NPS 3/4 (DN 20)** or nozzle size with hose-end connection.
  7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
  8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
  9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
- G. Controls
1. Refer to Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Boiler operating controls shall include the following devices and features:
    - a. Operating Pressure Control for Steam Boilers: Factory wired and mounted to cycle burner.
    - b. Low-Water Cutoff and Pump Control for Steam Boilers: Cycle feedwater pump(s) for makeup water control.
    - c. Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.  
**OR**  
Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At **0 deg F (minus 17 deg C)** outside-air temperature, set supply-water temperature at **200 deg F (93 deg C)**; at **60 deg F (15 deg C)** outside-air temperature, set supply-water temperature at **140 deg F (60 deg C)**.
    - d. Sequence of Operation for Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
      - 1) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
  2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
    - a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature for hot-water boiler or pressure for steam boiler.

- b. Low-Water Cutoff Switch: Electronic for hot-water boilers or Float and electronic for steam boilers probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
- c. Blocked Inlet Safety Switch: Manual-reset pressure switch field mounted on boiler combustion-air inlet.
- d. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- 3. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
  - a. Hardwired Points:
    - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
    - 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
  - b. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

#### H. Electrical Power

- 1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.  
**OR**  
Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
  - a. House in NEMA 250, Type 1 enclosure.
  - b. Wiring shall be numbered and color-coded to match wiring diagram.
  - c. Install factory wiring outside of an enclosure in a metal raceway.
  - d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
  - e. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
  - f. Provide each motor with overcurrent protection.

#### I. Venting Kits

- 1. Kit: Complete system, ASTM A 959, Type 29-4C stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap and dilution tank, and sealant.
- 2. Combustion-Air Intake: Complete system, stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

#### J. Source Quality Control

- 1. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
- 2. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
- 3. Allow the Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

### 1.3 EXECUTION

#### A. Boiler Installation



1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31..
  2. Vibration Isolation for Equipment Supported on Slabs-On -Grade: Elastomeric isolation pads **OR** mounts, **as directed**, with a minimum static deflection of **0.25 inch (6.35 mm)**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  3. Install gas-fired boilers according to NFPA 54.
  4. Assemble and install boiler trim.
  5. Install electrical devices furnished with boiler but not specified to be factory mounted.
  6. Install control wiring to field-mounted electrical devices.
- B. Connections
1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to boiler to allow service and maintenance.
  3. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
  4. Connect piping to boilers, except safety relief valve connections, with flexible connectors of materials suitable for service. Flexible connectors and their installation are specified in Division 23 Section "Common Work Results For Hvac".
  5. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
  6. Connect hot-water piping to supply- and return-boiler tapplings with shutoff valve and union or flange at each connection.
  7. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tapplings with shutoff valve and union or flange at each connection.
  8. Install piping from safety relief valves to nearest floor drain.
  9. Install piping from safety valves to drip-pan elbow and to nearest floor drain.
  10. Boiler Venting:
    - a. Install flue venting kit and combustion-air intake.
    - b. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks".
  11. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  12. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  2. Tests and Inspections:
    - a. Perform installation and startup checks according to manufacturer's written instructions.
    - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
    - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
    - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
      - 1) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature **OR** steam pressure, **as directed**.
      - 2) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  3. Remove and replace malfunctioning units and retest as specified above.





4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
5. Performance Tests, **as directed**:
  - a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
  - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
  - c. Perform field performance tests to determine capacity and efficiency of boilers.
    - 1) Test for full capacity.
    - 2) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.
  - d. Repeat tests until results comply with requirements indicated.
  - e. Provide analysis equipment required to determine performance.
  - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
  - g. Notify the Owner in advance of test dates.
  - h. Document test results in a report and submit to the Owner.

D. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 23 52 16 13

## SECTION 23 52 33 13 - WATER-TUBE BOILERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for water-tube boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged, factory-fabricated and -assembled, gas-fired, finned water-tube boilers, trim, and accessories for generating hot water.
2. This Section includes packaged, water-tube boilers, trim, and accessories for generating hot water or steam with the following configurations, burners, and outputs:
  - a. Factory and Field assembled.
  - b. Atmospheric gas, Forced-draft gas, Oil, and Combination gas and oil burner.

#### C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
  - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
    - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    - 2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
  - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
  4. Source quality-control test reports.
  5. Field quality-control test reports.
  6. Operation and maintenance data.
  7. Warranty: Special warranty specified in this Section.
  8. Other Informational Submittals:
    - a. ASME "A" Stamp Certification and Report: Submit "A" stamp certificate of authorization as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
    - b. Startup service reports.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. DOE Compliance: Minimum efficiency shall comply with 10 CFR 430, Subpart B, Appendix N, "Uniform Test Method for Measuring the Energy Consumption of Furnaces and Boilers."



5. I=B=R Compliance: Boilers shall be tested and rated according to HI's "Rating Procedure for Heating Boilers" and "Testing Standard for Commercial Boilers," with I=B=R emblem on a nameplate affixed to boiler.
6. UL Compliance: Test boilers for compliance with UL 726, "Oil-Fired Boiler Assemblies" **OR** UL 726, "Oil-Fired Boiler Assemblies" and UL 795, "Commercial-Industrial Gas Heating Equipment" **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

E. Warranty

1. Special Warranty for Finned Water-Tube Boilers: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchangers damaged by thermal shock and vent dampers of boilers that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Heat Exchangers: 20 years from date of Final Completion.
  - b. Warranty Period for Vent Dampers: Five years from date of Final Completion.
2. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace drums, tubes, headers, cabinets, atmospheric gas burners, and pressure vessels of boilers that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Drums, Tubes, Headers, Cabinets, and Atmospheric Gas Burner: Five years from date of Final Completion, pro rata.
  - b. Warranty Period for Pressure Vessel: 20 years from date of Final Completion, for thermal shock.

1.2 PRODUCTS

A. Finned Water-Tube Boilers

1. Description: Factory-fabricated, -assembled, and -tested boiler with tubes sealed into headers pressure tight, and set on a steel base; including insulated jacket, flue-gas vent, combustion-air intake connections, water supply and return connections, and controls.
2. Heat Exchanger:
  - a. Finned copper **OR** steel **OR** copper-nickel, **as directed**, tubing with stainless-steel baffles.
  - b. Bronze **OR** Cast-iron **OR** Steel, **as directed**, headers.
  - c. Single-pass **OR** Two-pass, **as directed**, horizontal **OR** vertical **OR** coil, **as directed**, configuration.
  - d. Tubes shall be sealed in header with silicone O-ring gaskets **OR** by welding **OR** by mechanically rolling tubes in header, **as directed**.
3. Combustion Chamber Internal Insulation: Interlocking panels of refractory insulation, high-temperature cements, mineral fiber, and ceramic refractory tile for service temperatures to **2000 deg F (1100 deg C)**.
4. Casing:
  - a. Jacket: Sheet metal **OR** Stainless steel, **as directed**, with snap-in or interlocking closures.
  - b. Control Compartment Enclosure: NEMA 250, Type 1A.
  - c. Finish: Baked enamel over primer **OR** Baked enamel over galvanizing **OR** Powder coated, **as directed**.
  - d. Insulation: Minimum **1-inch- (25-mm-)** **OR** **2-inch- (50-mm-)**, **as directed**, thick, mineral-fiber insulation surrounding the heat exchanger.
  - e. Draft Hood: Integral **OR** External, **as directed**.
  - f. Combustion-Air Connection: Inlet duct collar and sheet metal closure over burner compartment.
  - g. Mounting base to secure boiler with accessory for mounting on combustible surface, **as directed**.
    - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler pressure vessel, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And

Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.

5. Burner:
  - a. Burner Tubes and Orifices: Stainless steel, for natural **OR** propane, **as directed**, gas. Mount burner tubes in a slide-out burner drawer for ease of inspection, **as directed**.
    - 1) Sealed Combustion: Factory-mounted centrifugal fan to draw outside air into boiler and discharge into burner compartment.
    - 2) Direct Vent: Factory-mounted centrifugal fan to draw flue gas out of boiler and discharge into boiler vent.
  - b. Vertical Burner:
    - 1) High-temperature stainless steel **OR** Ceramic, **as directed**, to fire in a 360-degree pattern.
    - 2) Burner shall have a viewing port for observation of burner operation and a factory-mounted centrifugal fan to supply room **OR** outside, **as directed**, air through a replaceable 99 percent efficient (1-micrometer particles) filter, **as directed**, to boiler burner.
    - 3) Fan shall be controlled to prepurge and postpurge the combustion chamber before firing.
  - c. Gas Train for Commercial Boilers: Control devices and full-modulation **OR** on-off **OR** low-high-low **OR** proportional, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**. In addition to these requirements, include shutoff cock, pressure regulator, and control valve.
  - d. Gas Train for Residential Boilers: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
  - e. Pilot: Standing **OR** Intermittent-electric-spark **OR** Hot-surface, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
  - f. Flue-Gas Recirculation Fans: Centrifugal fans on burner assembly to recirculate flue gas to decrease oxides of nitrogen emissions to less than 30 ppm.
  - g. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
6. Trim:
  - a. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
  - b. Safety Relief Valve: ASME rated.
  - c. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
  - d. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
  - e. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end gate valve.
  - f. Circulation Pump: Non-overloading, in-line pump with split-capacitor motor having thermal-overload protection and lubricated bearings; designed to operate at specified boiler pressures and temperatures.
7. Controls:
  - a. Refer to Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Boiler operating controls shall include the following devices and features:
    - 1) Control transformer.
    - 2) Motorized Vent Damper: Interlocked with burner to open before burner starts. If damper fails to open, stop burner operation.
    - 3) Set-Point Adjust: Set points shall be adjustable.
    - 4) Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.**OR**



Sequence of Operation: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At **0 deg F (minus 17 deg C)** outside-air temperature, set supply-water temperature at **200 deg F (93 deg C)**; at **60 deg F (15 deg C)** outside-air temperature, set supply-water temperature at **140 deg F (60 deg C)**.

- 5) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
  - b. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
    - 1) High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature.
    - 2) Water Flow Switch: Automatic-reset paddle-switch shall prevent burner operation on low water flow.
    - 3) Blocked Vent Safety Switch: Manual-reset switch factory mounted on draft diverter.
    - 4) Rollout Safety Switch: Factory mounted on boiler combustion chamber.
    - 5) Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
  - c. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
    - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
    - 2) Control: On/off operation, hot water supply temperature set-point adjustment, **as directed**.
    - 3) A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.
- B. Steel **OR** Flexible, **as directed**, Water-Tube Boilers
1. Description: Factory-fabricated and assembled **OR** Field-assembled, **as directed**, water-tube boiler with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, supply and return connections, and controls.
  2. Heat-Exchanger Design: Straight steel tubes rolled into steel headers.
    - a. Accessible head plates at both ends.
    - b. Handholes or couplings, **as directed**, in headers for water-side inspections.
    - c. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
    - d. Lifting lugs on top of boiler.
    - e. Built-in air separator.
  3. Heat-Exchanger Design: Bent steel tubes swaged **OR** welded, **as directed**, into steel headers with membrane waterwall design, **as directed**.
    - a. Limit tube configurations to two **OR** four, **as directed**.
    - b. Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
    - c. Accessible inspection ports in drum, mud legs, and tube manifolds.
    - d. Lifting lugs on top of boiler.
    - e. Built-in air separator.
  4. Combustion Chamber: Equipped with minimum **2-1/2-inch (64-mm) OR 3-inch (75-mm) OR 4-inch (100-mm)**, **as directed**, **2700 deg F (1482 deg C)** poured refractory on floor and minimum **2-inch (50-mm) OR 3-1/2-inch (89-mm)**, **as directed**, lap-jointed cast refractory with fiber-blanket joint seals on side walls. Combustion chamber shall have flame observation ports in front and back **OR** back, **as directed**.
  5. Casing:
    - a. Insulation: Minimum **2-inch (50-mm)** thick, lightweight refractory; **1-inch (25-mm)** thick insulating board; galvanized-steel membrane, and **2-inch (50-mm)** thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber **OR 2-inch (50-mm)**

- thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber, **as directed**.
- b. Top Flue Connection: Constructed of aluminized steel **OR** stainless steel, **as directed**.
  - c. Jacket: Mirror-finish stainless steel, with screw-fastened closures.  
**OR**  
Jacket: Sheet metal **OR** Galvanized sheet metal, **as directed**, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
  - d. Mounting base to secure boiler to concrete base.
    - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
  - e. Control Compartment Enclosure: NEMA 250, Type 1A.
  - 6. Draft Diverter **OR** Barometric Damper, **as directed**: Galvanized-steel assembly with flue-gas thermometer.
  - 7. Burner - Atmospheric Gas Burners:
    - a. Burner and Orifices: Stainless steel **OR** Cast iron, **as directed**, for natural **OR** propane, **as directed**, gas.
    - b. Gas Train for Commercial Boilers: Control devices and full-modulation **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
    - c. Gas Train for Residential Boilers: Combination gas valve with manual shutoff, pressure regulator, and pilot adjustment.
    - d. Pilot: Standing **OR** Intermittent-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
  - 8. Burner - Forced-Draft Gas Burners:
    - a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for natural **OR** propane, **as directed**, gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
    - b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
      - 1) Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
        - a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - c. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in AGA **OR** ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
    - d. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
    - e. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
      - 1) Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
  - 9. Burner - Oil Burners:
    - a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
    - b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
      - 1) Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
        - a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - c. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.



- 1) Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
- 2) Oil Piping Specialties:
  - a) Suction-line, manual, gate valve.
  - b) Removable-mesh oil strainer.
  - c) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
  - d) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
  - e) Nozzle-line, solenoid-safety-shutoff oil valve.
- d. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid using cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
- e. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
  - 1) Maximum Oxides of Nitrogen Emissions: 30 ppm.
10. Burner - Combination Gas and Oil Burners:
  - a. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and natural **OR** propane, **as directed** gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
  - b. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
    - 1) Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - a) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - c. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI, **as directed**.
    - 1) Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
    - 2) Oil Piping Specialties:
      - a) Suction-line, manual, gate valve.
      - b) Removable-mesh oil strainer.
      - c) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
      - d) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
      - e) Nozzle-line, solenoid-safety-shutoff oil valve.
    - d. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
    - e. Gas Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
    - f. Oil Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
    - g. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
      - 1) Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
  11. Trim for Hot-Water Boilers:
    - a. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
    - b. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
    - c. Safety Relief Valve: ASME rated.



- d. Pressure and Temperature Gage: Minimum **3-1/2-inch- (89-mm-)** diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
- e. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
- f. Drain Valve: Minimum **NPS 3/4 (DN 20)** hose-end gate valve.
- g. Tankless Heater: Carbon-steel **OR** Bronze, **as directed**, header with copper-tube heat exchanger, mounted in a port of upper drum and sealed with fiber gasket.
  - 1) Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
  - 2) Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
- 12. Trim for Steam Boilers:
  - a. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
  - b. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
  - c. Safety Relief Valve:
    - 1) Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
    - 2) Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
      - a) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
  - d. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage shall have normal operating pressure about 50 percent of full range.
  - e. Water Column: Minimum **12-inch (300-mm)** glass gage with shutoff cocks.
  - f. Drain Valves: Minimum **NPS 3/4 (DN 20)** or nozzle size with hose-end connection.
  - g. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
  - h. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
  - i. Stop-Check Valves: Factory-installed, stop-check valve and stop valve at boiler outlet with free-blow drain valve factory installed between the two valves and visible when operating stop-check valve.
  - j. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in a port of upper manifold and sealed with fiber gasket.
    - 1) Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
    - 2) Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.
- 13. Controls:
  - a. Refer to Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Boiler operating controls shall include the following devices and features:
    - 1) Control transformer.
    - 2) Set-Point Adjust: Set points shall be adjustable.
    - 3) Operating Pressure Control for Steam Boilers: Factory wired and mounted to cycle burner.
    - 4) Low-Water Cutoff and Pump Control for Steam Boilers: Cycle feedwater pump(s) for makeup water control.

- 5) Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.  
**OR**  
Sequence of Operation for Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At 0 deg F (minus 17 deg C) outside-air temperature, set supply-water temperature at 200 deg F (93 deg C); at 60 deg F (15 deg C) outside-air temperature, set supply-water temperature at 140 deg F (60 deg C).
- 6) Sequence of Operation for Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
- 7) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
- b. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
  - 1) High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature for hot-water boiler or design pressure for steam boiler.
  - 2) Low-Water Cutoff Switch: Electronic (for hot-water boilers) or Float and electronic (for steam boilers) probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
  - 3) Blocked Vent Safety Switch (Atmospheric Boilers): Manual-reset switch factory mounted on draft diverter.
  - 4) Rollout Safety Switch (Atmospheric Boilers): Factory mounted on boiler combustion chamber.
  - 5) Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
- c. Building Automation System Interface: Factory install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
  - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
  - 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
  - 3) A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.

C. Electrical Power

1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.  
**OR**  
Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
  - a. House in NEMA 250, Type 1 enclosure.
  - b. Wiring shall be numbered and color-coded to match wiring diagram.
  - c. Install factory wiring outside of an enclosure in a metal, **as directed**, raceway.
  - d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
  - e. Provide branch power circuit to each motor and to controls with disconnect switch or circuit breaker, **as directed**.

- f. Provide each motor with overcurrent protection.

D. Venting Kits

1. Vent Damper (for Finned Water-Tube Boilers): Motorized, UL listed for use on atmospheric burner boiler equipped with draft hood; motor to open and close damper; stainless-steel vent coupling and damper blade; keyed wiring harness connector plug; and dual-position switches to permit burner operation.
2. Kit: Complete system, ASTM A 959, Type 29-4C, **as directed**, stainless steel, pipe, vent terminal, thimble, indoor plate, vent adapter, condensate trap, and sealant.
3. Combustion-Air Intake: Stainless steel, pipe, vent terminal with screen, inlet air coupling, and sealant.

E. Source Quality Control

1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
2. Burner and Hydrostatic Test (for Factory-Assembled Boilers): Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
3. Allow the Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

1.3 EXECUTION

A. Boiler Installation

1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of **0.25 inch (6.35 mm)**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install gas-fired boilers according to NFPA 54.
4. Install oil-fired boilers according to NFPA 31.
5. Assemble boiler tubes in sequence and seal each tube joint.
6. Assemble and install boiler trim.
7. Install electrical devices furnished with boiler but not specified to be factory mounted.
8. Install control wiring to field-mounted electrical devices.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
4. Connect oil piping full size to burner inlet with shutoff valve and union.
5. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.
6. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tappings with shutoff valve and union or flange at each connection.
7. Install piping from safety relief valves to nearest floor drain (for hot-water boilers).
8. Install piping from safety valves to drip-pan elbow and to nearest floor drain (for steam boilers).
9. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
10. Boiler Flue Venting (for Finned Water-Tube Boilers):
  - a. Install venting kit and combustion-air intake.



- b. Connect full size to boiler connections. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks".
- 11. Connect breeching to full size of boiler outlet. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for venting materials.
- 12. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for recirculation duct materials.
- 13. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
- 14. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

- 1. Perform tests and inspections and prepare test reports.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- 2. Tests and Inspections:
  - a. Perform installation and startup checks according to manufacturer's written instructions.
  - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
  - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
  - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - 1) Burner Test (for Field-Assembled Boilers): Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.
    - 2) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature **OR** steam pressure, **as directed**.
    - 3) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- 3. Remove and replace malfunctioning units and retest as specified above.
- 4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
- 5. Performance Tests, as directed:
  - a. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
  - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
  - c. Perform field performance tests to determine the capacity and efficiency of the boilers.
    - 1) For dual-fuel boilers, perform tests for each fuel.
    - 2) Test for full capacity.
    - 3) Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40 and 20, **as directed**, percent of full capacity. Determine efficiency at each test point.
  - d. Repeat tests until results comply with requirements indicated.
  - e. Provide analysis equipment required to determine performance.
  - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
  - g. Notify the Owner in advance of test dates.
  - h. Document test results in a report and submit to the Owner.

D. Demonstration

- 1. Train the Owner's maintenance personnel to adjust, operate, and maintain boilers.

END OF SECTION 23 52 33 13



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Task	Specification	Specification Description
23 52 33 16	23 52 33 13	Water-Tube Boilers

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## SECTION 23 52 36 00 - FIRE-TUBE BOILERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for fire-tube boilers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged, factory-fabricated and -assembled boilers, trim, and accessories for generating hot water **OR** steam, **as directed**, with the following configurations and burners:
  - a. Horizontal, fire-tube, Vertical, fire-tube, and Fire-box boiler.
  - b. Gas, Oil, and Combination gas and oil burner.

#### C. Submittals

1. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.
  - a. Design calculations and vibration isolation base details, signed and sealed by a qualified professional engineer.
    - 1) Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
    - 2) Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
  - b. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that boiler, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.
8. Other Informational Submittals:
  - a. ASME Stamp Certification and Report: Submit "A," "S," or "PP" stamp certificate of authorization, as required by authorities having jurisdiction, and document hydrostatic testing of piping external to boiler.
  - b. Startup service reports.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.
3. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."
4. UL Compliance: Test Boilers for compliance with UL 726, "Oil-Fired Boiler Assemblies" **OR** UL 726, "Oil-Fired Boiler Assemblies" and UL 795, "Commercial-Industrial Gas Heating Equipment" **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**. Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.





#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace front- and rear-door refractories and heat exchangers of boilers that fail in materials or workmanship within specified warranty period.
  - a. Horizontal, Fire-Tube and Fire-Box Boilers: Refractory in front and rear doors, 10 years from date of startup by factory-authorized personnel.
  - b. Vertical, Fire-Tube Boilers and Heat Exchanger: Five years from date of Final Completion, if following water-treatment program recommended by manufacturer.

### 1.2 PRODUCTS

#### A. Manufactured Units - Horizontal, Fire-Tube Boilers

1. Description: Factory-fabricated, -assembled, and -tested, horizontal, fire-tube boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water supply and return connections, and controls.
2. Pressure Vessel Design: Straight, steel tubes rolled **OR** welded, **as directed**, into steel headers. Three **OR** Four, **as directed**, passes with dry-back **OR** wet-back, **as directed**, design. Minimum heat-exchanger surface of **5 sq. ft./bhp (2.1 sq. m/10 kW)**. Include the following accessories:
  - a. Handholes for water-side inspections.
  - b. Lifting lugs on top of boiler.
  - c. Minimum **NPS 1 (DN 25)** hose-end drain valves at shell low point.
  - d. For hot-water boilers only:
    - 1) Tappings or flanges for supply- and return-water piping.
    - 2) Built-in air separator.
  - e. For steam boilers only:
    - 1) Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
    - 2) Tappings for steam supply, makeup, level controls, and chemical treatment.
3. Front and Rear Doors:
  - a. Bolted **OR** Hinged **OR** Davited, **as directed**, sealed with heat-resistant gaskets and fastened with lugs and cap screws.
  - b. Designed so tube sheets and flues are fully accessible for inspection or cleaning when doors are open.
  - c. Include observation ports in doors at both ends of boiler for inspection of flame conditions.
  - d. Door refractory **OR** insulation, **as directed**, shall be accessible for inspection and maintenance.
4. Casing:
  - a. Insulation: Minimum **2-inch- (50-mm-)** thick, mineral-fiber insulation surrounding the boiler shell.
  - b. Flue Connection: Flange at top of boiler.
  - c. Jacket: Galvanized sheet **OR** Sheet, **as directed**, metal, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
  - d. Mounting base to secure boiler to concrete base.
    - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
  - e. Control Compartment Enclosure: NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**.
5. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum **3-1/2-inch- (89-mm-)** diameter dial.

#### B. Manufactured Units - Vertical, Fire-Tube Boilers

1. Description: Factory-fabricated, -assembled, and -tested, vertical, fire-tube boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water supply and return connections, and controls.
  2. Pressure Vessel Design: Straight, steel pipe welded in a concentric pattern to separate flue-gas and heating media to form two **OR** four, **as directed**, passes with welded fins to improve heat transfer in secondary flue-gas passages. Include the following accessories:
    - a. Handholes for water-side inspections.
    - b. Lifting lugs on top of boiler.
    - c. Minimum **NPS 1 (DN 25)** hose-end drain valves at water passage low point.
    - d. For hot-water boilers only:
      - 1) Tappings or flanges for supply- and return-water piping.
      - 2) Built-in air separator.
    - e. For steam boilers only:
      - 1) Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
      - 2) Tappings for steam supply, makeup, level controls, and chemical treatment.
  3. Combustion Chamber: Equipped with flame retainer to lengthen flame-residence time.
  4. Casing:
    - a. Insulation: Minimum **4-inch- (100-mm-)** thick, mineral-fiber insulation surrounding the heat exchanger and combustion chamber.
    - b. Flue Connection: Top connection, constructed of aluminized **OR** stainless, **as directed**, steel.
    - c. Jacket: Mirror-finish stainless steel with screw-fastened closures.  
**OR**  
Jacket: Galvanized sheet **OR** Sheet, **as directed**, metal, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
    - d. Mounting base to secure boiler to concrete base.
      - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 22 Section "Identification For Plumbing Piping And Equipment" when mounting base is anchored to building structure.
    - e. Control Compartment Enclosure: NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**.
  5. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum **3-1/2-inch- (89-mm-)** diameter dial.
- C. Manufactured Units - Fire-Box Boilers
1. Description: Factory-fabricated, -assembled, and -tested, fire-box boilers with heat exchanger sealed pressure tight, built on a steel base; including insulated jacket, flue-gas vent, water supply and return connections, and controls.
  2. Pressure Vessel Design: Straight, steel tubes rolled **OR** welded, **as directed**, into steel headers. Three passes with wet-back design. Minimum heat-exchanger surface of **5 sq. ft./bhp (2.1 sq. m/10 kW)**. Include the following features and accessories:
    - a. Tube Size and Thickness: Minimum **NPS 2 (DN 50)**, minimum **0.105 inch (2.667 mm)** thick.
    - b. Brass washout plugs.
    - c. Steel turbulators.
    - d. Lifting lugs on top of boiler.
    - e. Minimum **NPS 1 (DN 25)** hose-end drain valves at shell low point.
    - f. For hot-water boilers only:
      - 1) Tappings or flanges for supply- and return-water piping.
      - 2) Built-in air separator.
    - g. For steam boilers only:
      - 1) Accessible drain and blowdown tappings, both high and low, for surface and mud removal.
      - 2) Tappings for steam supply, makeup, level controls, and chemical treatment.

3. Combustion Chamber: Welded steel, waterwall and -floor design **OR** water-leg design with refractory insulation poured in the floor, **as directed**. Flame observation port.
4. Casing:
  - a. Insulation: Minimum **2-inch- (50-mm-)** thick, foil-backed, **as directed**, mineral-fiber insulation surrounding the boiler shell.
  - b. Insulated removable smoke boxes and reversing chamber cover.
  - c. Flue Connection: Steel top **OR** rear, **as directed**.
  - d. Jacket: Sheet metal, with screw-fastened closures and baked-enamel **OR** powder-coated, **as directed**, protective finish.
  - e. Control Compartment Enclosure: NEMA 250, Type 1 **OR** 1A **OR** 4 **OR** 4X **OR** 12, **as directed**.
  - f. Mounting base to secure boiler to concrete base.
    - 1) Seismic Fabrication Requirements: Fabricate mounting base and attachment to boiler, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
5. Barometric Damper: Galvanized-steel assembly with flue-gas thermometer having a minimum **3-1/2-inch- (89-mm-)** diameter dial.

#### D. Burner For Forced-Draft Gas Burners

1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for natural **OR** propane, **as directed**, gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
  - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
4. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
5. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
  - a. Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.

#### E. Burner For Oil Burners

1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
  - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
3. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
  - a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing **300-psig (2070-kPa)** discharge pressure and **15-inch Hg (50.7-kPa)** vacuum.
  - b. Oil Piping Specialties:
    - 1) Suction-line, manual, gate valve.
    - 2) Removable-mesh oil strainer.
    - 3) **0- to 30-inch Hg (0- to 101.3-kPa)** vacuum; **0- to 30-psig (0- to 207-kPa)** vacuum-pressure gage.

- 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
    - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
  4. Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
  5. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
    - a. Maximum Oxides of Nitrogen Emissions: 30 ppm.
- F. Burner For Combination Gas And Oil Burners
1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser for fuel oil and natural **OR** propane, **as directed**, gas. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
  2. Blower: Forward-curved centrifugal fan integral to burner, directly driven by motor; with adjustable, dual-blade damper assembly and locking quadrant to set air-fuel ratio.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  3. Oil Supply: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
    - a. Oil Pump: Two-stage, gear-type oil pump integral to and directly driven by blower, **as directed**, shall be capable of producing 300-psig (2070-kPa) discharge pressure and 15-inch Hg (50.7-kPa) vacuum.
    - b. Oil Piping Specialties:
      - 1) Suction-line, manual, gate valve.
      - 2) Removable-mesh oil strainer.
      - 3) 0- to 30-inch Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
      - 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
      - 5) Nozzle-line, solenoid-safety-shutoff oil valve.
  4. Gas Train: Control devices and modulating **OR** on-off **OR** low-high-low, **as directed**, control sequence shall comply with requirements in ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
  5. Gas Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
  6. Oil Pilot: Intermittent **OR** Interrupted, **as directed**, -electric-spark pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
  7. Flue-Gas Recirculation: Burner connections shall be equipped for recirculating flue gas.
    - a. Maximum Oxides of Nitrogen Emissions: 20 **OR** 30, **as directed**, ppm.
- G. Trim For Hot-Water Boilers
1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
  2. Aquastat Controllers: Operating, firing rate, **as directed**, and high limit.
  3. Safety Relief Valve: ASME rated.
  4. Pressure and Temperature Gage: Minimum 3-1/2-inch- (89-mm-) diameter, combination water-pressure and -temperature gage. Gages shall have operating-pressure and -temperature ranges so normal operating range is about 50 percent of full range.
  5. Boiler Air Vent: Automatic **OR** Manual, **as directed**.
  6. Drain Valve: Minimum NPS 3/4 (DN 20) hose-end gate valve.
  7. Tankless Heater: Carbon-steel **OR** Bronze, **as directed**, header with copper-tube heat exchanger, mounted in a port of upper drum and sealed with fiber gasket.
    - a. Tappings NPS 2 (DN 50) and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.



- b. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

#### H. Trim For Steam Boilers

1. Include devices sized to comply with ANSI B31.1, "Power Piping **OR** ANSI B31.9, "Building Services Piping", **as directed**.
2. Pressure Controllers: Operating, firing rate, **as directed**, and high limit.
3. Safety Relief Valve:
  - a. Size and Capacity: As required for equipment according to ASME Boiler and Pressure Vessel Code.
  - b. Description: Fully enclosed steel spring with adjustable pressure range and positive shutoff; factory set and sealed.
    - 1) Drip-Pan Elbow: Cast iron and having threaded inlet and outlet with threads complying with ASME B1.20.1.
4. Pressure Gage: Minimum **3-1/2-inch (89-mm)** diameter. Gage shall have normal operating pressure about 50 percent of full range.
5. Water Column: Minimum **12-inch (300-mm)** glass gage with shutoff cocks.
6. Drain Valves: Minimum **NPS 3/4 (DN 20)** or nozzle size with hose-end connection.
7. Blowdown Valves: Factory-installed bottom and surface, slow-acting blowdown valves same size as boiler nozzle. Blowdown valves shall be combination of slow and quick acting as required by ANSI B31.1, **as directed**.
8. Stop Valves: Boiler inlets and outlets, except safety relief valves or preheater inlet and outlet, shall be equipped with stop valve in an accessible location as near as practical to boiler nozzle and same size or larger than nozzle. Valves larger than **NPS 2 (DN 50)** shall have rising stem.
9. Stop-Check Valves: Factory-installed, stop-check valve and stop valve for field installation at boiler outlet with free-blow drain valve for field installation between the two valves and visible when operating stop-check valve.
10. Tankless Heater: Carbon-steel header with copper-tube heat exchanger, mounted in a port of upper manifold and sealed with fiber gasket.
  - a. Tappings **NPS 2 (DN 50)** and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
  - b. Tappings **NPS 2-1/2 (DN 65)** and Larger: Flanged ends according to ASME B16.5 for steel and stainless-steel flanges, and according to ASME B16.24 for copper and copper-alloy flanges.

#### I. Controls

1. Refer to Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Boiler operating controls shall include the following devices and features:
  - a. Control transformer.
  - b. Set-Point Adjust: Set points shall be adjustable.
  - c. Operating Pressure Control for steam boilers: Factory wired and mounted to cycle burner.
  - d. Low-Water Cutoff and Pump Control for steam boilers: Cycle feedwater pump(s) **OR** Operate feedwater pump(s) continuously and modulate valve, **as directed**, for makeup water control.
  - e. Sequence Of Operation For Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain space temperature in response to thermostat with heat anticipator located in heated space.  
**OR**  
Sequence Of Operation For Hot-Water Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to reset supply-water temperature inversely with outside-air temperature. At **0 deg F (minus 17 deg C)** outside-air temperature, set supply-water temperature at **200 deg F (93 deg C)**; at **60 deg F (15 deg C)** outside-air temperature, set supply-water temperature at **140 deg F (60 deg C)**.



- f. Sequence Of Operation For Steam Boilers: Electric, factory-fabricated and field-installed panel to control burner firing rate to maintain a constant steam pressure. Maintain pressure set point plus or minus 10 percent.
            - 1) Include automatic, alternating-firing sequence for multiple boilers to ensure maximum system efficiency throughout the load range and to provide equal runtime for boilers.
  - 2. Burner Operating Controls: To maintain safe operating conditions, burner safety controls limit burner operation.
    - a. High Cutoff: Manual **OR** Automatic, **as directed**, reset stops burner if operating conditions rise above maximum boiler design temperature for hot-water boiler **OR** design pressure for steam boiler, **as directed**.
    - b. Low-Water Cutoff Switch: Electronic for hot-water boilers **OR** Float and electronic for steam boilers, **as directed**, probe shall prevent burner operation on low water. Cutoff switch shall be manual **OR** automatic, **as directed**, -reset type.
    - c. Audible Alarm: Factory mounted on control panel with silence switch; shall sound alarm for above conditions.
  - 3. Building Automation System Interface: Factory-install hardware and software to enable building automation system to monitor, control, and display boiler status and alarms.
    - a. Hardwired Points:
      - 1) Monitoring: On/off status, common trouble alarm **OR** low water level alarm, **as directed**.
      - 2) Control: On/off operation, hot water supply temperature set-point adjustment **OR** steam pressure adjustment, **as directed**.
    - b. A communication interface with building automation system shall enable building automation system operator to remotely control and monitor the boiler from an operator workstation. Control features available, and monitoring points displayed, locally at boiler control panel shall be available through building automation system.
- J. Electrical Power
  - 1. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22..  
**OR**  
Single-Point Field Power Connection: Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to boiler.
    - a. House in NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
    - b. Wiring shall be numbered and color-coded to match wiring diagram.
    - c. Install wiring outside of an enclosure in a metal, **as directed**, raceway.
    - d. Field power interface shall be to wire lugs **OR** fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
    - e. Provide branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
    - f. Provide each motor with overcurrent protection.
- K. Source Quality Control
  - 1. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
  - 2. Burner and Hydrostatic Test for factory-assembled boilers: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
  - 3. Allow the Owner access to source quality-control testing of boilers. Notify the Owner 14 days in advance of testing.

### 1.3 EXECUTION

#### A. Boiler Installation

1. Install boilers level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of **0.25 inch (6.35 mm)**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install gas-fired boilers according to NFPA 54.
4. Install oil-fired boilers according to NFPA 31.
5. Assemble and install boiler trim.
6. Install electrical devices furnished with boiler but not specified to be factory mounted.
7. Install control wiring to field-mounted electrical devices.

#### B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to boiler to allow service and maintenance.
3. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.
4. Connect oil piping full size to burner inlet with shutoff valve and union.
5. Connect hot-water piping to supply- and return-boiler tapplings with shutoff valve and union or flange at each connection.
6. Connect steam and condensate piping to supply-, return-, and blowdown-boiler tapplings with shutoff valve and union or flange at each connection.
7. Install piping from safety relief valves to nearest floor drain, for hot-water boilers.
8. Install piping from safety valves to drip-pan elbow and to nearest floor drain, for steam boilers.
9. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.
10. Connect breeching full size to boiler outlet. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for venting materials.
11. Install flue-gas recirculation duct from vent to burner. Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for recirculation duct materials.
12. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
13. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
  - a. Perform installation and startup checks according to manufacturer's written instructions.
  - b. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
  - c. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.
  - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - 1) Burner Test for field-assembled boilers: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency.



- 2) Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level, and water temperature **OR** steam pressure, **as directed**.
    - 3) Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  3. Remove and replace malfunctioning units and retest as specified above.
  4. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
  5. Performance Tests, **as directed**:
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
    - b. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment in order to comply.
    - c. Perform field performance tests to determine the capacity and efficiency of boilers.
      - 1) For dual-fuel boilers, perform tests for each fuel.
      - 2) Test for full capacity.
      - 3) Test for boiler efficiency at low fire, 20, 40, 60, 80, 100, 80, 60, 40 and 20, **as directed**, percent of full capacity. Determine efficiency at each test point.
    - d. Repeat tests until results comply with requirements indicated.
    - e. Provide analysis equipment required to determine performance.
    - f. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
    - g. Notify the Owner in advance of test dates.
    - h. Document test results in a report and submit to the Owner.
- D. Demonstration
  1. Train the Owner's maintenance personnel to adjust, operate, and maintain boilers.

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Task	Specification	Specification Description
23 52 39 13	23 52 36 00	Fire-Tube Boilers

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## SECTION 23 53 16 00 - FEEDWATER EQUIPMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for feedwater equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Feedwater pumps and receivers.
  - b. Vacuum-type feedwater pumps and receivers.

#### C. Definition

1. NPSH: Net-positive suction head.

#### D. Submittals

1. Product Data: For each type of product indicated. Include rated capacity, temperature and NPSH required, pump performance curves with selection points clearly indicated, and furnished specialties and accessories.
2. Shop Drawings: Include plans, elevations, sections, details, dimensions, weights, loadings, required clearances, method of field assembly, and attachments to other work.
  - a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that feedwater equipment, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Field quality-control test reports.
5. Operation and Maintenance Data.

#### E. Quality Assurance

1. Regulatory Requirements: Fabricate and test unit according to ASME PTC 12.1, "Closed Feedwater Heaters."
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. ASME Compliance: ASME B31.1, "Power Piping," for systems more than 15 psig (104 kPa); ASME B31.9, "Building Services Piping," for systems equal to or less than 15 psig (104 kPa). Safety valves and pressure vessels shall bear the appropriate ASME label.

#### F. Delivery, Storage, And Handling

1. Preparation for Shipping: Clean flanges and exposed-metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.
2. Store units in dry location.
3. Retain protective flange covers and machined-surface protective coatings during storage.
4. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
5. Comply with manufacturer's written rigging instructions.

### 1.2 PRODUCTS

#### A. Feedwater Units

1. Description: Factory-assembled and -tested unit consisting of a receiver, simplex **OR** duplex, **as directed**, feedwater pumps, controls, and the following features and accessories:
  - a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.
  - b. Level gage glass, reflex flat type, **as directed**, with stops at top and bottom.
  - c. Lifting eyes.
  - d. Companion flanges.
  - e. Pump, suction and discharge isolation valve, inlet strainer, discharge check valve, and liquid-filled pressure gage.
  - f. Makeup Water Assembly: Float operated with integral valve **OR** Electric level controller and valve, **as directed**; with inlet strainer and three-valve bypass.
  - g. Feedwater Heater: Sparge tube, thermostat, and control valve.
  - h. Factory-Installed Pipe, **NPS 2-1/2 (DN 65)** and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
    - 1) Cast-Iron Threaded Fittings: ASME B16.4; Class 125 **OR** 250, **as directed**.
    - 2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
    - 3) Forged-Steel Fittings: ASME B16.11, Class 3000.
    - 4) Malleable-Iron Unions: ASME B16.39; Class 150 **OR** 300, **as directed**.
    - 5) Forged-Steel Unions: MSS SP-83, Class 3000.
  - i. Factory-Installed Pipe, **NPS 3 (DN 80)** and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
    - 1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
    - 2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
2. Receiver:
  - a. Material: Close-grain cast iron **OR** Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
  - b. Additional corrosion protection:
    - 1) **0.07-inch (1.8-mm) OR 0.13-inch (3.3-mm) OR 0.19-inch (4.8-mm)**, **as directed**, thickness allowance.
    - 2) Electrolytic corrosion-inhibitor anode.
  - c. Finish: Primer **OR** Primer under enamel topcoat **OR** Primer under epoxy topcoat, **as directed**.
  - d. Factory-Applied Insulation and Jacket: Minimum thickness of **2 inches (50 mm)** for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
  - e. Mounting Arrangement: Recessed below floor **OR** Floor mounted, **as directed**.
  - f. Mounting Frame: Structural-steel stand to support receiver and pumps. Fabricate stand with bracing adequate for seismic forces according to authorities having jurisdiction and to allow anchoring mounting frame to floor, **as directed**.
3. Vertical Feedwater Pump: Flange-mounted, close-coupled, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of at least **225 deg F (107 deg C)**; with the following features:
  - a. Impeller: Bronze **OR** Stainless steel, **as directed**.
  - b. Seals: Mechanical.
  - c. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
4. Horizontal Feedwater Pump: Base-mounted, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of at least **225 deg F (107 deg C)**; with the following features:
  - a. Impeller: Bronze **OR** Stainless steel, **as directed**.

- b. Coupling: Close **OR** Flexible, **as directed**.
- c. Seals: Mechanical.
- d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- 5. Control panel shall be unit mounted and factory wired and include the following:
  - a. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
  - b. Single-point field power interface to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
    - 1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
  - c. NEMA-rated motor controller for each motor, and include a hand-off-auto switch and overcurrent protection.
    - 1) Alternating controls for duplex units with intermittent operation as indicated by control sequence.
  - d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - e. Wiring outside of an enclosure in a metal, **as directed**, raceway. Make connections to motor with liquidtight conduit.
  - f. Removable control mounting plate.
  - g. Visual indication of status and alarm with momentary test push button, **as directed**.
  - h. Audible alarm and silence switch.
  - i. Visual indication of elapsed run time, graduated in hours.
  - j. Fused control-circuit transformer.
  - k. Microprocessor-based controller.
- 6. Feedwater Simplex-Pump Control Sequence:
  - a. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
  - b. Visual indication of pump on and off, **as directed**, status.
  - c. Visual and audible, **as directed**, alarm indication of pump failure.
- 7. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with operating and standby pump):
  - a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
  - b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
  - c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
  - d. Visual indication of pump on and off, **as directed**, status.
  - e. Visual indication of pump lead/lag status.
  - f. Visual and audible, **as directed**, alarm indication of pump failure.
- 8. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with continuous pump operation and modulating control valve):
  - a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
  - b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
  - c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
  - d. Lead pump failure automatically starts lag pump.  
**OR**  
Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
  - e. Visual indication of pump on and off, **as directed**, status.
  - f. Visual indication of pump lead/lag status.
  - g. Visual and audible, **as directed**, alarm indication of pump failure.
- 9. Receiver Makeup Water Control Sequence:
  - a. Electric level controller operates electric control valve to maintain receiver water-level set point.  
**OR**





- Mechanical float operates integral valve to maintain water-level set point.
    - b. Visual and audible, **as directed**, alarm indication of low and high, **as directed**, receiver-water level.
  - 10. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
    - a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, receiver low-water-level alarm, receiver high-water-level alarm, feedwater temperature, **as directed**.

B. Feedwater Unit With Vacuum Producer

1. Description: Receiver mounted, consisting of multijet vacuum producer, centrifugal pump and motor assembly mounted on separation chamber, and automatic pressure and water temperature controls. Include the following accessories:
  - a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.
  - b. Vacuum Gage: Dial-type register in **inches of mercury** (kPa).
  - c. Level Gage Glass: Stops top and bottom.
  - d. Air-suction check valve.
  - e. Lifting eyes.
  - f. Companion flanges.
  - g. Low-water cutoff switch.
  - h. Cooling-Water Control: Aquastat, inlet strainer, and electric valve.
  - i. Air vent.
  - j. Overflow drain from vacuum-producer receiver.
  - k. Factory-Installed Pipe, **NPS 2-1/2 (DN 65)** and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
    - 1) Cast-Iron Threaded Fittings: ASME B16.4; Class 125 **OR** 250, **as directed**.
    - 2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
    - 3) Forged-Steel Fittings: ASME B16.11, Class 3000.
    - 4) Malleable-Iron Unions: ASME B16.39; Class 150 **OR** 300, **as directed**.
    - 5) Forged-Steel Unions: MSS SP-83, Class 3000.
  - l. Factory-Installed Pipe, **NPS 3 (DN 80)** and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
    - 1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
    - 2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
2. Vacuum-Producer Reservoir and Vacuum Receiver:
  - a. Material: Close-grain cast iron **OR** Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
  - b. Additional corrosion protection:
    - 1) **0.07-inch (1.8-mm) OR 0.13-inch (3.3-mm) OR 0.19-inch (4.8-mm)**, **as directed**, thickness allowance.
    - 2) Electrolytic corrosion-inhibitor anode.
  - c. Finish: Primer **OR** Primer under enamel topcoat **OR** Primer under epoxy topcoat, **as directed**.
  - d. Factory-Applied Insulation and Jacket: Minimum thickness of **2 inches (50 mm)** for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
  - e. Mounting Arrangement: Recessed below floor **OR** Floor mounted, **as directed**.
  - f. Mounting Frame: Structural-steel stand to support receiver and pumps. Fabricate stand with bracing adequate for seismic forces according to authorities having jurisdiction and to allow anchoring mounting frame to floor, **as directed**.

3. Vertical Vacuum-Producer Pump: Flange-mounted, close-coupled, single-stage, radially split-case-design centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of at least **225 deg F (107 deg C)**; with the following features:
  - a. Impeller: Bronze.
  - b. Shaft: Stainless steel.
  - c. Seals: Mechanical.
  - d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
4. Horizontal Vacuum-Producer Pump: Base-mounted, single-stage, radially split-case-design centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of at least **225 deg F (107 deg C)**; with the following features:
  - a. Impeller: Bronze.
  - b. Shaft: Stainless steel.
  - c. Coupling: Close **OR** Flexible, **as directed**.
  - d. Seals: Mechanical.
  - e. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
5. Vertical Feedwater Pump: Flange-mounted, close-coupled, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of at least **225 deg F (107 deg C)**; with the following features:
  - a. Impeller: Bronze **OR** Stainless steel, **as directed**.
  - b. Seals: Mechanical.
  - c. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
6. Horizontal Feedwater Pump: Base-mounted, single-stage, **OR** multistage, **as directed**, radially split-case-design centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of at least **225 deg F (107 deg C)**; with the following features:
  - a. Impeller: Bronze **OR** Stainless steel, **as directed**.
  - b. Coupling: Close **OR** Flexible, **as directed**.
  - c. Seals: Mechanical.
  - d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
7. Control panel shall be unit mounted and factory wired and include the following:
  - a. Vacuum Switches for Simplex Vacuum-Producer Pumps: Include pressure adjustment, and test push button. Factory set to operate pump between **3 and 6 inches of mercury (10.1 and 20.2 kPa)**.  
**OR**  
Vacuum Switches for Duplex Vacuum-Producer Pumps: Include pressure adjustment, and test push button. Factory set so one pump operates for **3 to 5 inches of mercury (10.1 to 16.9 kPa)** and both pumps operate for **4 to 6 inches of mercury (13.5 to 20.2 kPa)**.
  - b. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
  - c. Single-point field power interface to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
    - 1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
  - d. NEMA-rated motor controller for each motor and include a hand-off-auto switch and overcurrent protection.
    - 1) Alternating control for units with intermittent operation as indicated by control sequence.
  - e. Terminal blocks with numbered and color-coded wiring to match wiring diagram.

- f. Wiring outside of an enclosure in a metal, **as directed**, raceway. Make connections to motor with liquidtight conduit.
- g. Removable control mounting plate.
- h. Visual indication of status and alarm with momentary test push button, **as directed**.
- i. Audible alarm and silence switch.
- j. Visual indication of elapsed run time, graduated in hours.
- k. Fused control-circuit transformer.
8. Vacuum-Producer Control Sequence:
  - a. Cycle pumps to maintain vacuum-pressure set point.
  - b. Visual indication of pump on and off, **as directed**, status.
  - c. Visual and audible, **as directed**, alarm indication of pump failure.
9. Feedwater Simplex-Pump Control Sequence:
  - a. Boiler water-level controller starts and stops pump to maintain boiler water-level set point.
  - b. Visual indication of pump on and off, **as directed**, status.
  - c. Visual and audible, **as directed**, alarm indication of pump failure.
10. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with operating and standby pump):
  - a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
  - b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
  - c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
  - d. Visual indication of pump on and off, **as directed**, status.
  - e. Visual indication of pump lead/lag status.
  - f. Visual and audible, **as directed**, alarm indication of pump failure.
11. Feedwater Duplex-Pump Control Sequence (for duplex-pump units with continuous pump operation and modulating control valve):
  - a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
  - b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
  - c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
  - d. Lead pump failure automatically starts lag pump.  
**OR**  
Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
  - e. Visual indication of pump on and off, **as directed**, status.
  - f. Visual indication of pump lead/lag status.
  - g. Visual and audible, **as directed**, alarm indication of pump failure.
12. Makeup Water Control Sequence:
  - a. Electric level controller operates electric control valve to maintain water temperature set point.
  - b. Visual and audible, **as directed**, alarm indication of low and high, **as directed**, water level.
13. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
  - a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, receiver low-water-level alarm, receiver high-water-level alarm, feedwater temperature, **as directed**.

### 1.3 EXECUTION

#### A. Installation

1. Install feedwater unit level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31.
  2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of **0.25 inch (6.35 mm)**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  3. Install unit to permit access for maintenance.
  4. Support piping independent of pumps.
  5. Install base-mounted pumps on concrete bases with grouted base frames.
  6. Install parts and accessories shipped loose.
  7. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  8. Install piping adjacent to machine to allow service and maintenance.
  9. Connect makeup water piping and cooling-water piping with reduced-pressure backflow preventers.
  10. Install overflow drain piping to nearest floor drain.
  11. Install vents and extend to outdoors; terminate with elbow turned down and an insect screen.
  12. Adjust boiler water-level controls to properly stage unit.
  13. Set field-adjustable, makeup water and cooling-water controls.
  14. Clean equipment internally; remove coatings applied for protection during shipping and storage, foreign material, and oily residue according to manufacturer's written instructions.
  15. Clean strainers.
- B. Field Quality Control
1. Perform tests and inspections and prepare test reports.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  2. Tests and Inspections:
    - a. Inspect field-assembled components, equipment installation, and piping and electrical connections for compliance with manufacturer's written instructions.
    - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - c. Check bearing lubrication.
    - d. Verify proper motor rotation.
    - e. Start up service.
    - f. Report results in writing.
  3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 23 53 16 00

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## SECTION 23 53 16 00a - DEAERATORS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for deaerators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged, factory-assembled deaerators.

#### C. Definitions

1. Feedwater Pump: Pump that moves feedwater from the deaerator to the boiler.
2. Transfer Pump: Pump that moves feedwater from the surge tank to the deaerator.
3. NPSH: Net-positive suction head.

#### D. Submittals

1. Product Data: For each type of product indicated. Include rated makeup water, feedwater, and steam flow rates; working pressure; tank capacities; storage capacity in minutes; temperature and NPSH required; pump performance curves with selection points clearly indicated; furnished specialties; and accessories.
2. Shop Drawings: For deaerators, signed and sealed by a qualified professional engineer; include plans, elevations, sections, details, dimensions, weights, loadings, required clearances, and attachments to other work.
  - a. For installed products indicated to comply with design loads, include structural analysis data.
  - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing deaerator bases.
  - c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that deaerators, accessories, and components will withstand seismic forces as indicated in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Field quality-control test reports.
5. Operation and Maintenance Data: For deaerators to include in emergency, operation, and maintenance manuals.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASME Compliance: ASME B31.1, "Power Piping," for systems more than 15 psig (104 kPa); ASME B31.9, "Building Services Piping," for systems equal to or less than 15 psig (104 kPa). Safety valves and pressure vessels shall bear the appropriate ASME label.

#### F. Delivery, Storage, And Handling

1. Protect flanges, pipe openings, nozzles, bearings, and couplings from damage during shipping and storage.
2. Comply with manufacturer's written rigging instructions.
3. Deliver deaerators as factory-assembled units with protective crating and covering.

## 1.2 PRODUCTS

### A. Manufactured Units

1. Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, single-compartment deaerator, and a separate packaged surge tank with transfer and feedwater pumps and controls to supply feedwater to deaerator, **as directed**.  
**OR**  
Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, two-compartment deaerator. One compartment for deaeration and one for surge volume, each with its own transfer and feedwater pumps and controls.  
**OR**  
Horizontal **OR** Vertical, **as directed**, packed-column **OR** spray **OR** tray, **as directed**, single-compartment deaerator and separate surge tank, both mounted on same factory-fabricated stand with necessary transfer and feedwater pumps and controls.
2. Material for Wetted Components: Components in contact with water that has not been deaerated shall be made of Type 304 **OR** 316, **as directed**, stainless steel.
3. Adjustable Spray Valves: Type 316 stainless steel. Arrange spray valves for counterflow of steam and condensate and so corrosive gases being vented do not contact deaerator's head or shell.
4. Vent Condenser: Stainless steel, with automatic and manual vent valves.
5. Deaerator and Storage Tank:
  - a. Material: Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
  - b. Additional Corrosion Protection:
    - 1) **0.07-inch (1.8-mm) OR 0.13-inch (3.3-mm) OR 0.19-inch (4.8-mm)**, **as directed**, thickness allowance.
    - 2) Electrolytic corrosion-inhibitor anode.
  - c. Access: Manhole in deaerator and storage tank for access to internal components for inspection and service.
  - d. Factory-Applied Insulation and Jacket: Minimum thickness of **2 inches (50 mm)**, **as directed**, for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
  - e. Factory-Installed Pipe, **NPS 2-1/2 (DN 65)** and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
    - 1) Cast-Iron Threaded Fittings: ASME B16.4, Class 125 **OR** 250, **as directed**.
    - 2) Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
    - 3) Forged-Steel Fittings: ASME B16.11, Class 3000.
    - 4) Malleable-Iron Unions: ASME B16.39, Class 150 **OR** 300, **as directed**.
    - 5) Forged-Steel Unions: MSS SP-83, Class 3000.
  - f. Factory-Installed Pipe, **NPS 3 (DN 80)** and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
    - 1) Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
    - 2) Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
6. Accessories:
  - a. Lifting eyes.
  - b. Companion flanges.
  - c. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
  - d. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**.
  - e. Pump-discharge bypass relief valve **OR** orifice plate **OR** relief valve with orifice plate, **as directed**.



- f. Makeup Water Assembly:
  - 1) Factory-mounted modulating valve with mechanical level control, external float cage, and stainless-steel float.  
**OR**  
Factory **OR** Field, **as directed**, -mounted, electric, pilot-operated, solenoid **OR** modulating, **as directed**, valve with factory-mounted, probe-type, **as directed**, water-level controller.  
**OR**  
Factory **OR** Field, **as directed**, -mounted, pneumatic modulating valve with factory-mounted water-level controller.
  - 2) Factory **OR** Field, **as directed**, -mounted, three-valve bypass and inlet strainer.
- g. Steam Pressure-Reducing Valve(s): Steam **OR** Electric **OR** Pneumatic, **as directed**, operated with three-valve bypass, **as directed**, and sized to reduce boiler outlet pressure to the deaerator design pressure.
- h. Tank Overflow Drain: Sized to relieve full capacity at operating pressure.
- i. Safety Valve(s): ASME labeled and sized to relieve full capacity of pressure-reducing valve.
- j. Vents: Manual and automatic vent valves.
- k. Vacuum breaker.
- l. Meters and Gages:
  - 1) Full-height, water-level gage glass, reflex flat type, **as directed**, and stop valve set.
  - 2) Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**, mounted to measure temperature in storage and steam, **as directed**, section of tank.
  - 3) Pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**, mounted to measure pressure in steam section of tank.
- m. Provision for chemical injection quill.
- n. Chemical injection quill.
- o. Sampling connection with valve.
- p. Tank drain connection with valve.
- q. Oxygen test kit.
- 7. Support Frame: Structural-steel frame for supporting tank and pumps. Weld or bolt to tank.
  - a. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only, **as directed**.
- 8. Feedwater Pump: Cast-iron, flange **OR** base, **as directed**, -mounted volute; with bronze **OR** stainless-steel, **as directed**, multistage centrifugal **OR** turbine, **as directed**, impeller, renewable bronze case ring, and stainless-steel shaft.
  - a. Seals: Mechanical, suitable for 250 deg F (121 deg C).
  - b. Pump Motor: Vertical **OR** Horizontal, **as directed**, open dripproof **OR** totally enclosed **OR** totally enclosed fan-cooled, **as directed**, enclosure, close **OR** flexible, **as directed**, coupled to pump. Comply with requirements in Division 15 Section "Motors."
- 9. Feedwater Pump Control Panel: Factory mounted and wired and including the following:
  - a. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
  - b. Single-point, field power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
    - 1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
  - c. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor.
    - 1) Alternating control as indicated by control sequence for each pump.
  - d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - e. Metal raceway **OR** Raceway, **as directed**, for factory-installed wiring outside of enclosures. Make connections to motor with liquidtight conduit.
  - f. Removable control mounting plate.

- g. Visual indication of status and alarm with momentary test push button, **as directed**.
  - h. Audible alarm and silence switch.
  - i. Visual indication of elapsed run time, graduated in hours.
  - j. Fusible, control-circuit transformer.
  - k. Microprocessor-based controller.
  - 10. Feedwater Pump Start-Stop Control Sequence (for intermittent pump operation):
    - a. Boiler water-level controller starts and stops lead pump to maintain boiler water-level set point.
    - b. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
    - c. Lead pump failure, lag pump automatically starts if lead pump cannot maintain set point **OR** is started manually, **as directed**.
    - d. Visual indication of pump on **OR** on and off, **as directed**, status.
    - e. Visual indication of pump lead/lag status.
    - f. Visual **OR** Visual and audible, **as directed**, alarm indication of pump failure.
  - 11. Feedwater Pump Continuous Control Sequence (for continuous pump operation and modulating control valve):
    - a. Pump runs continuously while boiler operates. Electric interlock with boiler control starts lead pump when boiler starts.
    - b. Boiler water-level controller modulates feedwater control valve to maintain boiler water-level set point. Valve closes when boiler is off.
    - c. Lead and lag pumps alternate after each start **OR** to equalize run time, **as directed**.
    - d. Lead pump failure automatically starts lag pump.  
**OR**  
Feedwater pressure controller starts and stops lag pump to maintain feedwater pressure set point.
    - e. Visual indication of pump on **OR** on and off, **as directed**, status.
    - f. Visual indication of pump lead/lag status.
    - g. Visual **OR** Visual and audible, **as directed**, alarm indication of pump failure.
  - 12. Makeup Water Control Sequence:
    - a. Electric level controller operates electric control valve to maintain tank water-level set point.  
**OR**  
Pneumatic level controller operates pneumatic control valve to maintain tank water-level set point.  
**OR**  
Mechanical float operates valve to maintain water-level set point.
    - b. Visual **OR** Visual and audible, **as directed**, alarm indication of low **OR** low and high, **as directed**, tank water level.
  - 13. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
    - a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, low-water level alarm, high-water level alarm, feedwater temperature, **as directed**.
- B. Surge Tank
- 1. Description: Factory-assembled and -tested unit consisting of a condensate receiver, transfer pumps, and controls.
  - 2. Accessories:
    - a. Liquid-filled industrial **OR** Bimetal dial-type, **as directed**, thermometer graduated in Fahrenheit **OR** Celsius **OR** both Fahrenheit and Celsius, **as directed**.
    - b. Level gage glass, reflex flat type, **as directed**, with stops at top and bottom.
    - c. Lifting eyes.
    - d. Companion flanges.
    - e. Pump suction piping with vortex breaker, isolation valve, strainer, and flexible connector.
    - f. Pump discharge piping with check valve, isolation valve, and liquid-filled pressure gage graduated in pounds force per square inch **OR** kilopascals **OR** both pounds force per square inch and kilopascals, **as directed**.

- g. Pump-discharge bypass relief valve **OR** orifice plate **OR** relief valve with orifice plate, **as directed**.
3. Factory-Installed Pipe, **NPS 2-1/2 (DN 65)** and Smaller: ASTM A 53/A 53M, Type S (seamless), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with threaded joints and fittings.
  - a. Cast-Iron Threaded Fittings: ASME B16.4, Class 125 **OR** 250, **as directed**.
  - b. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150 **OR** 300, **as directed**.
  - c. Forged-Steel Fittings: ASME B16.11, Class 3000.
  - d. Malleable-Iron Unions: ASME B16.39, Class 150 **OR** 300, **as directed**.
  - e. Forged-Steel Unions: MSS SP-83, Class 3000.
4. Factory-Installed Pipe, **NPS 3 (DN 80)** and Larger: ASTM A 53/A 53M, Type E (electric-resistance welded), Grade B; or ASTM A 106, Type S, Grade B, Schedule 40 **OR** 80, **as directed**; with welded joints and carbon-steel fittings and flanges.
  - a. Wrought-Steel Fittings: ASME B16.9, wall thickness to match adjoining pipe.
  - b. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, Class 150 **OR** 300, **as directed**, including bolts, nuts, and gaskets.
5. Tank:
  - a. Material: Welded carbon steel **OR** Welded carbon steel galvanized after fabrication **OR** Stainless steel, **as directed**.
  - b. Additional Corrosion Protection:
    - 1) **0.07-inch (1.8-mm) OR 0.13-inch (3.3-mm) OR 0.19-inch (4.8-mm)**, **as directed**, thickness allowance.
    - 2) Electrolytic corrosion-inhibitor anode.
  - c. Access: Manhole in tank for access to internal components for inspection and service.
  - d. Factory-Applied Insulation and Jacket: Minimum thickness of **2 inches (50 mm)** for mineral-fiber pipe and tank insulation. Cover insulation with painted steel **OR** stucco-embossed aluminum **OR** stainless-steel, **as directed**, jacket.
6. Support Frame: Structural-steel frame for supporting tank. Weld or bolt to tank.
  - a. Fabricate support frame with bracing adequate for seismic forces according to authorities having jurisdiction and to allow installation by anchoring deaerators to floor only.
7. Transfer Pump: Vertical, flange-mounted, close-coupled, single-stage **OR** multistage, **as directed**, radially split-case centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of **225 deg F (107 deg C)**; with the following features:
  - a. Impeller: Bronze **OR** Stainless steel, **as directed**.
  - b. Seals: Mechanical.
  - c. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
8. Transfer Pump: Horizontal, base-mounted, single-stage **OR** multistage, **as directed**, radially split-case centrifugal pump; rated for **175-psig (1205-kPa)** minimum working pressure and a continuous water temperature of **225 deg F (107 deg C)**; with the following features:
  - a. Impeller: Bronze **OR** Stainless steel, **as directed**.
  - b. Coupling: Close **OR** Flexible, **as directed**.
  - c. Seals: Mechanical.
  - d. Motor: Open dripproof **OR** Totally enclosed **OR** Totally enclosed fan-cooled, **as directed**, enclosure. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
9. Transfer Pump Control Panel: Factory mounted and wired and including the following:
  - a. NEMA 250, Type 1 **OR** 4 **OR** 4X **OR** 12, **as directed**, enclosure.
  - b. Single-point, field power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**.
    - 1) Branch power circuit to each motor and to controls with a disconnect switch or circuit breaker, **as directed**.
  - c. NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor.

- 1) Alternating control indicated by control sequence for each pump.
  - d. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - e. Metal raceway **OR** Raceway, **as directed**, for factory-installed wiring outside of enclosures. Make connections to motor with liquidtight conduit.
  - f. Removable control mounting plate.
  - g. Visual indication of on/off status and pump failure alarm with momentary test push button, **as directed**.
  - h. Audible alarm and silence switch.
  - i. Visual indication of elapsed run time, graduated in hours.
  - j. Fusible, control-circuit transformer.
  - k. Microprocessor-based controller.
  10. Transfer Pump Start-Stop Control Sequence: Deaerator water-level controller controls lead pump; alternator switches lead and lag pump(s) after each start **OR** to equalize run time, **as directed**; failure of lead pump switches to lag pump and sounds audible alarm, **as directed**.
  11. Transfer Pump Continuous-Run Control Sequence: Lead pump runs continuously while deaerator is operating; deaerator water-level controller modulates water-level-control valve; lead and lag pump(s) switch to equalize run time; lag pump operates if lead pump fails; pump failure sounds audible alarm, **as directed**.
  12. Building Management System Interface: Factory install hardware to enable building management system to monitor and display points.
    - a. Hardwired Monitoring Points: On/off status for each pump, failure alarm for each pump, low-water level alarm, high-water level alarm, **as directed**.
- C. Factory Finishes
1. Manufacturer's standard prime-coat finish ready for field painting.
  2. Manufacturer's standard paint in standard colors, applied to factory-assembled and -tested unit before shipping.
  3. Do not paint aluminum, galvanized-steel, and stainless-steel surfaces.
- D. Source Quality Control
1. Fabricate and label deaerator tanks according to ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.
  2. Factory install and test piping that connects pumps to tanks according to ASME B31.1, "Power Piping" **OR** ASME B31.9, "Building Services Piping," **as directed**.
  3. Factory test performance and certify test results on packaged deaerator units, according to ASME PTC 12.3, before shipping to Project.

### 1.3 EXECUTION

#### A. Examination

1. Before deaerator installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting performance, maintenance, and operations.
  - a. Final deaerator locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
  - b. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Installation

1. Install deaerators level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac", and concrete materials and installation requirements are specified in Division 31.
2. Vibration Isolation: Elastomeric isolator pads **OR** mounts, **as directed**, with a minimum static deflection of **0.25 inch (6.35 mm)**. Vibration isolation devices and installation requirements are

- specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Install deaerators to permit access for service and maintenance.
  4. Support piping independent of pumps.
  5. Install base-mounted pumps on concrete base with grouted base frame.
  6. Install all parts and materials not factory installed.
  7. Extend overflow drains to floor drains.
  8. Extend vent piping to outside and terminate with manufacturer-approved cap furnished with deaerator.
  9. Install piping adjacent to machine to allow service and maintenance.
- C. Connections
1. Steam and condensate piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Connect steam and condensate piping to tank tapplings with shutoff valves and unions or flanges at each connection.
  3. Connect condensate drains, pump-discharge piping, vents, overflow drains, makeup water, steam supply, and cooling water piping.
- D. Field Quality Control
1. Perform tests and inspections and prepare test reports.
  2. Tests and Inspections:
    - a. Inspect field-assembled components and equipment installation, including piping and electrical connections, for compliance with requirements.
    - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - c. Verify bearing lubrication.
    - d. Verify proper motor rotation.
    - e. Test Reports: Prepare a written report to record the following:
      - 1) Test procedures used.
      - 2) Test results that comply with requirements.
      - 3) Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
  3. Remove and replace malfunctioning equipment and retest as specified above.
- E. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
  2. Complete installation and startup checks according to manufacturer's written instructions and do the following:
    - a. Set deaerator makeup water-level controls.
    - b. Verify bearing lubrication.
    - c. Verify proper motor rotation.
    - d. Start pumps according to manufacturer's written instructions.
- F. Adjusting And Cleaning
1. Adjust initial temperature and pressure set points.
  2. Set field-adjustable switches and circuit-breaker trip ranges.
  3. Clean strainers.
- G. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain deaerators.

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## SECTION 23 54 16 13 - FURNACES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for furnaces. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Gas-fired, noncondensing, Gas-fired, condensing, Oil-fired, and Electric furnaces and accessories complete with controls.
  - b. Air filters.
  - c. Air cleaners.
  - d. Ultraviolet germicidal lights.
  - e. Humidifiers.
  - f. Ventilation heat exchangers.
  - g. Refrigeration components.

#### C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each of the following:
  - a. Furnace.
  - b. Thermostat.
  - c. Humidistat.
  - d. Air filter.
  - e. Air cleaner.
  - f. Ultraviolet germicidal light.
  - g. Humidifier.
  - h. Ventilation heat exchanger.
  - i. Refrigeration components.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - a. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and maintenance data.
4. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
  - c. Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
5. Warranty: Special warranty specified in this Section.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."





3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. Comply with NFPA 70.

E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of furnaces that fail in materials or workmanship within specified warranty period:
  - a. Warranty Period, Commencing on Date of Final Completion:
    - 1) Furnace Heat Exchanger: 10 years **OR** 20 years **OR** Lifetime, **as directed**.
    - 2) Integrated Ignition and Blower Control Circuit Board: Five years.
    - 3) Draft-Inducer Motor: Five years.
    - 4) High-Efficiency Oil Furnace Burner: Three years.
    - 5) Refrigeration Compressors: 10 years **OR** Lifetime, **as directed**.
    - 6) Evaporator and Condenser Coils: Five years.

## 1.2 PRODUCTS

A. Gas-Fired Furnaces, Noncondensing

1. General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3, "Gas-Fired Central Furnaces," and with NFPA 54.
2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
  - a. Cabinet interior around heat exchanger shall be factory-installed insulation.
  - b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
  - c. Factory paint external cabinets in manufacturer's standard color.
  - d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive **OR** belt drive **OR** direct or belt drive **OR** drive type indicated on Drawings, **as directed**.
  - a. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.  
**OR**  
Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.  
**OR**  
Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
4. Type of Gas: Natural **OR** Propane, **as directed**.
5. Heat Exchanger: Aluminized **OR** Stainless, **as directed**, steel.
6. Burner:
  - a. Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
  - b. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
7. Gas-Burner Safety Controls:
  - a. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
  - b. Flame Rollout Switch: Installed on burner box; prevents burner operation.
  - c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.

8. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.
  9. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.
  10. Vent Materials: Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks", for Type B metal vents.
- B. Gas-Fired Furnaces, Condensing
1. General Requirements for Gas-Fired, Condensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.47/CSA 2.3, "Gas-Fired Central Furnaces," and with NFPA 54.
  2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
    - a. Cabinet interior around heat exchanger shall be factory-installed insulation.
    - b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
    - c. Factory paint external cabinets in manufacturer's standard color.
    - d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.
    - a. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.  
**OR**  
 Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.  
**OR**  
 Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
  4. Type of Gas: Natural **OR** Propane, **as directed**.
  5. Heat Exchanger:
    - a. Primary: Aluminized **OR** Stainless, **as directed**, steel.
    - b. Secondary: Polyethylene-coated **OR** Stainless, **as directed**, steel.
  6. Burner:
    - a. Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
    - b. Ignition: Electric pilot ignition, with hot-surface igniter or electric spark ignition.
  7. Gas-Burner Safety Controls:
    - a. Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
    - b. Flame Rollout Switch: Installed on burner box; prevents burner operation.
    - c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
  8. Combustion-Air Inducer: Centrifugal fan with thermally protected motor and sleeve bearings prepurges heat exchanger and vents combustion products; pressure switch prevents furnace operation if combustion-air inlet or flue outlet is blocked.
  9. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; terminals for connection to accessories; diagnostic light with viewport, **as directed**.
  10. Accessories:
    - a. Combination Combustion-Air Intake and Vent: PVC plastic fitting to combine combustion-air inlet and vent through outside wall **OR** roof, **as directed**.
    - b. CPVC Plastic Vent Materials.
      - 1) CPVC Plastic Pipe: Schedule 40, complying with ASTM F 441/F 441M.



- 2) CPVC Plastic Fittings: Schedule 40, complying with ASTM F 438, socket type.
- 3) CPVC Solvent Cement: ASTM F 493.
  - a) Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - b) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- c. PVC Plastic Vent Materials:
  - 1) PVC Plastic Pipe: Schedule 40, complying with ASTM D 1785.
  - 2) PVC Plastic Fittings: Schedule 40, complying with ASTM D 2466, socket type.
  - 3) PVC Solvent Cement: ASTM D 2564.
    - a) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - b) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

#### C. Oil-Fired Furnaces

1. General Requirements for Oil-Fired Furnaces: Factory assembled, piped, wired, and tested; complying with UL 727 and with NFPA 31.
2. Cabinet: Steel **OR** Galvanized steel, **as directed**.
  - a. Cabinet interior around heat exchanger shall be factory-installed insulation.
  - b. Lift-out panels shall expose burners and all other items requiring access for maintenance.
  - c. Factory paint external cabinets in manufacturer's standard color.
  - d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive **OR** belt drive **OR** drive type indicated on Drawings, **as directed**.
  - a. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
4. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.  
**OR**  
Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
5. Heat Exchanger: Welded steel with ceramic-fiber liner **OR** refractory insert, **as directed**, at the burner in the combustion chamber. Minimum ~~2-inch-~~ (50-mm-) diameter access ports in heat exchanger to permit access for cleaning.
6. Burner: High-pressure atomizing type, with rubber-mounted, adjustable, combustion-air blower; integrated fuel pump; hinged, flame-inspection port; cadmium-sulfide flame sensor; electrodes; ignition transformer; and oil nozzle.
  - a. Time-Delay Relay: Limits time for establishing main flame.
  - b. Flame Sensor: Monitors flame and stops burner on flame failure.
  - c. Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
7. Barometric Draft Regulator: Match furnace; for mounting in flue.
8. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; and adjustable fan-on and fan-off timing; terminals for connection to accessories.
9. Vent Materials: Comply with requirements in Division 23 Section "Breechings, Chimneys, And Stacks" for Type B metal vents.

#### D. Electric Furnaces

1. General Requirements for Electric Furnaces: Factory assembled, piped, wired, and tested.
2. Cabinet: Steel, with duct liner downstream from cooling coil, **as directed**.
  - a. Duct Liner: Fiberglass, minimum ~~1/2 inch~~ (13 mm) **OR** ~~3/4 inch~~ (19 mm), **as directed**, thick, complying with ASTM C 1071 and having a coated surface exposed to airstream

complying with NFPA 90A or NFPA 90B and with NAIMA's "Fibrous Glass Duct Liner Standard."

- 1) Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  - b. Factory paint external cabinets in manufacturer's standard color.
  3. Fan: Centrifugal, factory balanced, resilient mounted, direct drive.
    - a. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - b. Special Motor Features: Single speed, Premium (TM) efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment", and with internal thermal protection and permanent lubrication.  
**OR**  
Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.  
**OR**  
Special Motor Features: Electronically controlled motor (ECM) controlled by integrated furnace/blower control.
  4. Electric-Resistant Heating Elements: Helix-wound, nickel-chromium wire-heating elements in ceramic insulators mounted on steel supports.
  5. Heating-Element Control: Sequencer relay with relay for each element; switches elements on and off, with delay between each increment; initiates, stops, or changes fan speed.
  6. Summer Fan Switch: Connected to permit independent on-off switch of unit fan.
- E. Thermostats And Humidistats
1. Solid-State Thermostat: Wall-mounting **OR** Freestanding **OR** Wireless, **as directed**, programmable, microprocessor-based unit with automatic **OR** manual, **as directed**, switching from heating to cooling, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, **as directed**, and battery backup protection against power failure for program settings.  
**OR**  
Single-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounting unit with fan on-automatic selector.  
**OR**  
Two-Stage, Heating-Cooling Thermostat: Adjustable, heating-cooling, wall-mounting unit with fan on-automatic selector.  
**OR**  
Single-Stage **OR** Two-Stage, **as directed**, Heating-Only Thermostat: Wall-mounting unit with fan on-automatic selector.  
**OR**  
Solid-State, Combination Thermostat and Humidistat: Wall-mounting **OR** Freestanding **OR** Wireless, **as directed**, programmable, microprocessor-based unit with automatic switching from heating to cooling and humidifying to dehumidifying, preferential rate control, seven-day programmability with minimum of four temperature presets per day, vacation mode, **as directed**, and battery backup protection against power failure for program settings.
  2. Humidistat: Adjustable, wall-mounting **OR** duct-mounting, **as directed**, unit.
  3. Control Wiring: Unshielded twisted-pair cabling.
    - a. No. 24 AWG, 100 ohm, four pair.
    - b. Cable Jacket Color: Blue.
  4. Controls shall comply with requirements in ASHRAE/IESNA 90.1, "Controls."
- F. Air Filters
1. Washable Filters: 1-inch- (25-mm-) thick, urethane pad.
  2. Disposable Filters: 1-inch- (25-mm-) thick fiberglass media with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**, in sheet metal frame.
  3. Charged Media Air Filters: Sheet metal housing arranged to be ducted in return-air duct connection to furnace, generates electrostatic charge; MERV 10 rating.



4. HEPA Air Filter Units: Sheet metal housing with fan arranged to be ducted to return-air duct connection to furnace, with activated carbon prefilter, high-efficiency particulate air (HEPA) disposable filter, and carbon VOC, **as directed**. HEPA shall be as follows:
  - a. Standard: UL 586, "High-Efficiency, Particulate, Air Filter Units."
  - b. Rating: ASHRAE 52.1, dust-spot efficiency of 65 percent; ASHRAE 52.2, 99.97 percent efficiency to 0.03-micrometer particle size.
  
- G. Air Cleaners
  1. Electronic Air Cleaners: Packaged system, including sheet metal housing, prefilter, power supply, and automatic control device, arranged for mounting in return-air duct at furnace; equip with on-off and test switches and pilot light.
    - a. Standard: UL 586, "High-Efficiency, Particulate, Air Filter Units."
    - b. Rating: ASHRAE 52.2, particle size to 0.01 micrometer.
    - c. Static Pressure Drop: Maximum **0.14-inch wg (35 Pa)** at **300-fpm (1.52-m/s)** air velocity.
  
- H. Ultraviolet Germicidal Lights
  1. Description: Lighting unit in metal housing arranged for installation in supply-air duct and controlled to cycle on and off with furnace fan, with one **OR** two, **as directed**, 75-W ultraviolet-light bulb(s).
  
- I. Humidifiers
  1. Minimum capacity rating indicated according to ARI 610, "Central System Humidifiers for Residential Applications."
  2. Media-wheel bypass type with bypass damper and motor-driven media wheel in reservoir with float-valve level control; arranged for mounting on return duct or plenum with bypass connection to supply duct.  
**OR**  
 Wetted-pad, continuous-drain, bypass type with bypass damper and water-flow control orifice; arranged for mounting on return duct or plenum with bypass connection to supply duct.  
**OR**  
 Fan-powered, wetted-pad, continuous-drain type with water-flow control orifice and motor; arranged for mounting on duct or plenum.  
**OR**  
 Pumped, fan-powered, wetted-pad type with reservoir-level control and pump and fan motors; arranged for mounting on duct or plenum.  
**OR**  
 Steam type with electric heating element in stainless-steel reservoir with float-valve level control; arranged for attachment to duct or plenum and for control by humidistat.
  3. Comply with applicable requirements in ASHRAE 62.1.
  
- J. Ventilation Air Heat Exchanger
  1. Cabinet: Steel, with factory-installed interior insulation and manufacturer's standard factory finish. Fabricate with space for piping and electrical conduits.
  2. Heat-Recovery Device: Fixed-plate, polypropylene copolymer (high-density plastic) heat-exchanger plates evenly spaced and sealed and arranged for counter airflow.
  3. Supply and Exhaust Fans: Forward curved centrifugal with direct drive. Motors comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  4. Filters: **1-inch- (25-mm-)** thick disposable type with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**, in galvanized-steel frame, mounted upstream of unit in both supply and exhaust airstreams.
  5. Wiring: Wire motors and controls so only external connections are required during installation.
  
- K. Refrigeration Components
  1. General Refrigeration Component Requirements:

- a. Refrigeration compressor, coils, and specialties shall be designed to operate with CFC-free refrigerants.
  - b. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
2. Refrigerant Coil: Copper tubes mechanically expanded into aluminum fins. Comply with ARI 210/240, "Unitary Air-Conditioning and Air-Source Heat Pump Equipment." Match size with furnace. Include condensate drain pan with accessible drain outlet complying with ASHRAE 62.1, **as directed**.
  - a. Refrigerant Coil Enclosure: Steel, matching furnace and evaporator coil, with access panel and flanges for integral mounting at or on furnace cabinet and galvanized sheet metal drain pan coated with black asphaltic base paint.
3. Refrigerant Line Kits: Annealed-copper suction and liquid lines factory cleaned, dried, pressurized with nitrogen, sealed, and with suction line insulated. Provide in standard lengths for installation without joints, except at equipment connections.
  - a. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I, **1/2 inch (13 mm) OR 1 inch (25 mm), as directed**, thick.
4. Refrigerant Piping: Comply with requirements in Division 23 Section "Refrigerant Piping".
5. Air-Cooled, Compressor-Condenser Unit:
  - a. Casing: Steel, finished with baked enamel, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
  - b. Compressor: Hermetically sealed reciprocating **OR** scroll, **as directed**, type.
    - 1) Crankcase heater.
    - 2) Restrained vibration **OR** Vibration, **as directed**, isolation mounts for compressor.
    - 3) Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    - 4) Two-speed compressor motors shall have manual-reset high-pressure switch and automatic-reset low-pressure switch.
    - 5) Refrigerant Charge: R-407C **OR** R-410A, **as directed**.
  - c. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
  - d. Heat-Pump Components: Reversing valve and low-temperature air cut-off thermostat.
  - e. Fan: Aluminum-propeller type, directly connected to motor.
  - f. Motor: Permanently lubricated, with integral thermal-overload protection.
  - g. Low Ambient Kit: Permits operation down to **45 deg F (7 deg C)**.
  - h. Mounting Base: Polyethylene.

### 1.3 EXECUTION

#### A. Installation

1. Install gas-fired furnaces and associated fuel and vent features and systems according to NFPA 54.
2. Install oil-fired furnaces and associated fuel and vent piping according to NFPA 31.
3. Suspended Units: Suspend from structure using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
  - a. Install seismic restraints to limit movement of furnace by resisting code-required seismic acceleration.
4. Base-Mounted Units: Secure units to substrate. Provide optional bottom closure base if required by installation conditions.
  - a. Anchor furnace to substrate to resist code-required seismic acceleration.
5. Controls: Install thermostats and humidistats at mounting height of **60 inches (1500 mm)** above floor.
6. Wiring Method: Install control wiring in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal control wiring except in unfinished spaces.





7. Install ground-mounted, compressor-condenser components on **4-inch- (100-mm-)** thick, reinforced concrete base; **4 inches (100 mm)** larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete". Coordinate anchor installation with concrete base.

**OR**

Install ground-mounted, compressor-condenser components on polyethylene mounting base.

8. Install roof-mounted, compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories". Anchor units to supports with removable, cadmium-plated fasteners.

**B. Connections**

1. Gas piping installation requirements are specified in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Drawings indicate general arrangement of piping, fittings, and specialties. Connect gas piping with union or flange and appliance connector valve.
2. Oil piping installation requirements are specified in Division 23 Section "Facility Fuel-oil Piping". Drawings indicate general arrangement of piping, fittings, and specialties. Connect oil piping with union or flange and ball **OR** gate, **as directed**, valve.
3. Install piping adjacent to equipment to allow service and maintenance.
4. Water piping installation requirements for furnaces with humidifiers are specified in Division 22 Section "Domestic Water Piping". Drawings indicate general arrangement of piping, fittings, and specialties. Connect water piping with union and ball valve.
5. Vent Connection, Noncondensing, Gas-Fired Furnaces: Connect Type B vents to furnace vent connection and extend outdoors. Type B vents and their installation requirements are specified in Division 23 Section "Breechings, Chimneys, And Stacks".
6. Vent and Outside-Air Connection, Condensing, Gas-Fired Furnaces: Connect plastic piping vent material to furnace connections and extend outdoors. Terminate vent outdoors with a cap and in an arrangement that will protect against entry of birds, insects, and dirt.
  - a. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
  - b. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
  - c. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
    - 1) Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
    - 2) CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
    - 3) PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
    - 4) Requirements for Low-Emitting Materials:
      - a) Use CPVC solvent cement that has a VOC content of 490 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
      - b) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
      - c) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
  - d. Slope pipe vent back to furnace or to outside terminal.
7. Vent Connections, Oil-Fired Furnaces: Connect Type L vents to furnace vent connection and extend outdoors. Type L vents and their installation requirements are specified in Division 23 Section "Breechings, Chimneys, And Stacks".
8. Connect ducts to furnace with flexible connector. Comply with requirements in Division 23 Section "Air Duct Accessories".
9. Connect refrigerant tubing kits to refrigerant coil in furnace and to air-cooled, compressor-condenser unit.



- a. Flared Joints: Use ASME B16.26 fitting and flared ends, following procedures in CDA's "Copper Tube Handbook."  
**OR**  
Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.  
**OR**  
Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- 10. Comply with requirements in Division 23 Section "Refrigerant Piping" for installation and joint construction of refrigerant piping.
- C. Field Quality Control
  - 1. Perform the following field tests and inspections and prepare test reports:
    - a. Perform electrical test and visual and mechanical inspection.
    - b. Leak Test: After installation, charge systems with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
    - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation, product capability, and compliance with requirements.
    - d. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
    - e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  - 2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
- D. Startup Service
  - 1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
    - a. Inspect for physical damage to unit casings.
    - b. Verify that access doors move freely and are weathertight.
    - c. Clean units and inspect for construction debris.
    - d. Verify that all bolts and screws are tight.
    - e. Adjust vibration isolation and flexible connections.
    - f. Verify that controls are connected and operational.
  - 2. Adjust fan belts to proper alignment and tension.
  - 3. Start unit according to manufacturer's written instructions and complete manufacturer's operational checklist.
  - 4. Measure and record airflows.
  - 5. Verify proper operation of capacity control device.
  - 6. After startup and performance test, lubricate bearings and adjust belt tension, **as directed**.
- E. Adjusting
  - 1. Adjust initial temperature and humidity set points.
  - 2. Set controls, burner, and other adjustments for optimum heating performance and efficiency. Adjust heat-distribution features, including shutters, dampers, and relays, to provide optimum heating performance and system efficiency.
- F. Cleaning
  - 1. After completing installation, clean furnaces internally according to manufacturer's written instructions.
  - 2. Install new filters in each furnace within 14 days after Final Completion.
- G. Demonstration
  - 1. Train Owner's maintenance personnel to adjust, operate, and maintain condensing units.



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END OF SECTION 23 54 16 13

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Task	Specification	Specification Description
23 54 19 00	23 54 16 13	Furnaces

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## SECTION 23 55 23 13 - RADIANT HEATING AND COOLING UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for radiant heating and cooling units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Electric radiant heaters.
  - b. Prefabricated electric radiant heating panels.
  - c. Hydronic heating and cooling panels.

#### C. Definitions

1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.

#### D. Submittals

1. Product Data: Include rated capacities, specialties, and accessories for each product indicated.
2. Manufacturer Seismic Qualification Certification.
3. Field quality-control test reports.
4. Operation and maintenance data.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### 1.2 PRODUCTS

#### A. Electric Radiant Heaters

1. Quartz Lamp Heating Elements: Coiled tungsten-wire heating element enclosed in clear quartz tube.
2. Quartz Tube Heating Elements: Nickel-chromium-wire heating element enclosed in quartz tube.
3. Metal-Sheathed Heating Elements: Nickel-chromium-wire heating element embedded in magnesium oxide powder and enclosed in metal sheath. Comply with UL 1030.
4. Comply with UL 499 and UL 2021, **as directed**.
5. Enclosures: Aluminized **OR** Stainless **OR** Painted, **as directed**, steel housing with anodized-aluminum reflector.
  - a. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
6. Unit Controls:
  - a. Line-voltage thermostat.
  - b. Enclosed contactor for remote thermostat.
  - c. Snow and ice detector with moisture sensor and integral temperature sensor.

#### B. Prefabricated Electric Radiant Heating Panels

1. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**. Comply with UL 2021.

- a. Panel: Minimum 0.0276-inch- (0.7-mm-) thick, galvanized-steel sheet back panel riveted to minimum 0.0396-inch- (1.0-mm-) thick, galvanized-steel sheet front panel with fused-on crystalline surface.
  - b. Heating Element: Powdered graphite sandwiched between sheets of electric insulation **OR** Insulated resistive wires, **as directed**.
  - c. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
  - d. Exposed-Side Panel Finish:
    - 1) Apply silk-screened finish to match appearance of Architect-selected acoustical ceiling tiles.  
**OR**  
Factory prime coated, ready for field painting.  
**OR**  
Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
  - e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
  2. Wall Thermostat: Bimetal, sensing elements calibrated from 55 to 90 deg F (13 to 32 deg C); with contacts suitable for low **OR** line, **as directed**, -voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.
  3. Capacities and Characteristics:
    - a. Nominal Panel Size: 24 by 24 inches (600 by 600 mm) **OR** 24 by 36 inches (600 by 900 mm) **OR** 24 by 48 inches (600 by 1200 mm) **OR** 24 by 60 inches (600 by 1500 mm), **as directed**.
    - b. Heating Capacity: 250 **OR** 375 **OR** 500 **OR** 570 **OR** 625 **OR** 750 **OR** 950, **as directed**, kW.
- C. Hydronic Heating And Cooling, **as directed**, Panels
1. Description: Modular **OR** Linear, **as directed**, sheet metal panel with serpentine water piping, suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**.
    - a. Panels: Minimum 0.0336-inch- (0.86-mm-) thick, galvanized-steel **OR** 0.0396-inch- (1.0-mm-) thick, aluminum, **as directed**, sheet.
    - b. Backing Insulation: Minimum 1-inch- (25-mm-) **OR** 2-inch- (50-mm-), **as directed**, thick, mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB with factory-applied jacket.
    - c. Exposed-Side Panel Finish:
      - 1) Apply silk-screened finish to match appearance of selected acoustical ceiling tiles.  
**OR**  
Factory prime coated, ready for field painting.  
**OR**  
Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
    - d. Factory Piping: ASTM B 88, Type L (ASTM B 88M, Type B) **OR** ASTM B 88, Type M (ASTM B 88M, Type C), **as directed**, copper tube with ASME B16.22 wrought-copper fittings and brazed joints. Piping shall be mechanically bonded to panel.
    - e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
    - f. Accessories:
      - 1) 5-inch (127-mm) **OR** 6-inch (152-mm) **OR** 8-inch (203-mm), **as directed**, panel with drape track recess.
      - 2) 5-inch (127-mm) male bullnose panel.
      - 3) 5-inch (127-mm) female bullnose panel.
      - 4) 4-inch (102-mm) male corner panel.
      - 5) 4-inch (102-mm) female corner panel.

- 6) Inside corner panel.
- 7) **1/2-inch (13-mm)** filler panel.
2. Capacities and Characteristics:
  - a. Nominal Panel Size: **24 by 24 inches (600 by 600 mm) OR 24 by 36 inches (600 by 900 mm) OR 24 by 48 inches (600 by 1200 mm) OR 24 by 60 inches (600 by 1500 mm), as directed.**
  - b. Piping Inlet and Outlet: **NPS 1/2 (DN 15).**

### 1.3 EXECUTION

#### A. Installation

1. Install radiant heating and cooling units level and plumb.
2. Suspend radiant heaters from structure.
3. Support for Radiant Heating and Cooling Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
  - a. Install a minimum of four ceiling support system rods or wires for each panel. Locate not more than **6 inches (150 mm)** from panel corners.
  - b. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
  - c. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two **3/4-inch (19-mm)** metal channels spanning and secured to ceiling tees.
  - d. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of 3.
4. Verify locations of thermostats with Drawings and room details before installation. Install devices **48 inches (1220 mm) OR 60 inches (1525 mm), as directed**, above finished floor.
5. Piping installation requirements are specified in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
6. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
7. Install piping adjacent to unit to allow service and maintenance.
8. Ground electric units according to Division 26 Section "Grounding And Bonding For Electrical Systems".
9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### B. Field Quality Control

1. Testing: Perform the following field tests and inspections and prepare test reports:
  - a. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and units.
2. Remove and replace malfunctioning units and retest as specified above.
3. After installing panels, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

END OF SECTION 23 55 23 13



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## SECTION 23 55 23 13a - RADIANT-HEATING ELECTRIC PANELS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for radiant-heating electric panels. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes prefabricated radiant-heating electric panels.

#### C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: For electric heating panels. Include plans, sections, details, and attachments to other work.
  - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and Maintenance Data: For electric heating panels to include in operation and maintenance manuals.
5. Warranty: Special warranty specified in this Section.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### 1.2 PRODUCTS

#### A. Prefabricated Radiant-Heating Electric Panels

1. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid **OR** surface mounting **OR** recessed mounting, **as directed**. Comply with UL 2021.
  - a. Panel: Minimum **0.0276-inch- (0.7-mm-)** thick, galvanized-steel sheet back panel riveted to minimum **0.0396-inch- (1.0-mm-)** thick, galvanized-steel sheet front panel with fused-on crystalline surface.
  - b. Heating Element:
    - 1) Powdered graphite sandwiched between sheets of electric insulation.  
**OR**  
Insulated resistive wires.
  - c. Electrical Connections: Nonheating, high-temperature, insulated-copper leads, factory connected to heating element.
  - d. Exposed-Side Panel Finish:
    - 1) Apply silk-screened finish to match appearance of selected acoustical ceiling tiles.
    - 2) Factory prime coated, ready for field painting.
    - 3) Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.
  - e. Surface-Mounting Trim: Sheet metal with baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, paint color as selected.

2. Wall Thermostat: Bimetal, sensing elements calibrated from **55 to 90 deg F** (**13 to 32 deg C**); with contacts suitable for low **OR** line, **as directed**, -voltage circuit, and manually operated on-off switch with contactors, relays, and control transformers.

### 1.3 EXECUTION

#### A. Installation

1. Install radiant-heating panels level and plumb.
2. Support for Radiant-Heating Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
  - a. Install a minimum of four ceiling support system rods or wires for each panel. Locate not more than **6 inches (150 mm)** from panel corners.
  - b. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
  - c. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two **3/4-inch (19-mm)** metal channels spanning and secured to ceiling tees.
  - d. Install at least one independent support rod or wire from structure to a tab on panel. Wire or rod shall have breaking strength of the weight of panel at a safety factor of 3.
3. Verify locations of thermostats with Drawings and room details before installation. Install devices **48 inches (1220 mm) OR 60 inches (1525 mm)**, **as directed**, above finished floor.

#### B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### C. Field Quality Control

1. Testing: Perform the following field tests and inspections and prepare test reports:
  - a. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - b. Test and adjust controls and safeties.
2. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 23 55 23 13a

## SECTION 23 55 33 00 - FUEL-FIRED UNIT HEATERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for fuel-fired unit heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes gas and oil-fired unit heaters.

#### C. Submittals

1. Product Data: For each type of fuel-fired unit heater indicated. Include rated capacities, operating characteristics, and accessories.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that fuel-fired unit heaters, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace heat exchanger of fuel-fired unit heater that fails in materials or workmanship within Two **OR Five, as directed**, years from date of Final Completion.

### 1.2 PRODUCTS

#### A. Gas-Fired Unit Heaters

1. Description: Factory assembled, piped, and wired, and complying with ANSI Z83.8/CSA 2.6.
2. Fuel Type: Design burner for natural **OR** propane, **as directed**, gas having characteristics same as those of gas available at Project site.
3. Type of Venting: Gravity **OR** Powered **OR** Indoor, separated combustion, power, **as directed**, vented.
4. Housing: Steel, with integral draft hood and inserts for suspension mounting rods.
  - a. External Casings and Cabinets: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface.
  - b. Suspension Attachments: Reinforce suspension attachments at connection to fuel-fired unit heaters.



- 1) Seismic Fabrication Requirements: Fabricate suspension attachments of fuel-fired unit heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fuel-fired unit heater is anchored to building structure.
5. Heat Exchanger: Aluminized **OR** Stainless, **as directed**, steel.
6. Burner Material: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
7. Unit Fan: Formed-steel **OR** Aluminum, **as directed**, propeller blades riveted to heavy-gage steel spider bolted to cast-iron hub, dynamically balanced, and resiliently mounted.
  - a. Fan-Blade Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
  - b. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 1) Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - 3) Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
8. Unit Fan: Steel, centrifugal fan dynamically balanced and resiliently mounted.
  - a. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
    - 1) Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
    - 2) Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
    - 3) Pulleys: Cast-iron, adjustable-pitch motor pulley.
  - b. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 1) Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - 3) Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
9. Controls: Regulated redundant gas valve containing pilot solenoid valve, electric gas valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
  - a. Gas Control Valve: Single stage **OR** Two stage **OR** Modulating, **as directed**.
  - b. Ignition: Standing pilot **OR** Electronically controlled electric spark with flame sensor, **as directed**.
  - c. Fan Thermal Switch: Operates fan on heat-exchanger temperature.
  - d. Vent Flow Verification: Flame rollout switch **OR** Differential pressure switch to verify open vent, **as directed**.
  - e. Control transformer.
  - f. High Limit: Thermal switch or fuse to stop burner.
  - g. Thermostats: Devices and wiring are specified in Division 23 Section "Instrumentation And Control For Hvac".
 

**OR**

Thermostat: Single-stage, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

**OR**

Thermostat: 2-stage, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.

**OR**

Thermostat: Single-stage type with duct-mounting sensor and 50 to 90 deg F (10 to 32 deg C) operating range.

**OR**

- Thermostat: 2-stage type with duct-mounting sensor and 50 to 90 deg F (10 to 32 deg C) operating range.
10. Discharge Louvers: Independently adjustable horizontal blades.
  11. Accessories:
    - a. Vertical discharge louvers.
    - b. Discharge Nozzle: Discharge at 25 to 65 degrees (0.44 to 1.13 radians) OR 50 to 90 degrees (0.87 to 1.57 radians), as directed, from horizontal.
    - c. Four-point suspension kit.
    - d. Summer fan switch.
    - e. Unit-mounted thermostat bracket.
    - f. Power Venter: Centrifugal aluminized-steel fan, with stainless-steel shaft; 120-V ac motor.
    - g. Concentric, Terminal Vent Assembly: Combined combustion-air inlet and power-vent outlet with wall or roof caps. Include adapter assembly for connection to inlet and outlet pipes, and flashing for wall or roof penetration.
- B. Oil-Fired Unit Heaters
1. Description: Factory assembled, piped, and wired, and complying with UL 731.
  2. Housing: Steel, with inserts for suspension mounting rods.
    - a. External Casings and Cabinets: Baked enamel OR Powder coating, as directed, over corrosion-resistant-treated surface.
    - b. Suspension Attachments: Reinforce suspension attachments at connection to fuel-fired unit heaters.
      - 1) Seismic Fabrication Requirements: Fabricate suspension attachments of fuel-fired unit heaters, accessories mountings, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fuel-fired unit heater is anchored to building structure.
  3. Heat Exchanger: Minimum 0.09-inch (2.2-mm) steel.
  4. Burners: Flame-retention, pressure-atomizing, forced-draft, gun type; with integral fuel pump and electronic spark ignition and flame safety.
    - a. Safety Device: Oil-pressure switch.
  5. Unit Fan: Propeller fan with aluminum blades dynamically balanced and resiliently mounted.
    - a. Steel fan-blade guard.
    - b. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
      - 3) Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
  6. Unit Fan: Steel, centrifugal fan dynamically balanced and resiliently mounted.
    - a. Belt driven with adjustable-pitch motor sheave.
    - b. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motors: Totally enclosed with internal thermal-overload protection and complying with Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
      - 3) Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
  7. Controls: Factory piped and prewired to electrical junction box mounted on unit, including the following:
    - a. Control Transformer: Integrally mounted, 120 to 24 V ac.
    - b. Cad-cell safety system.
    - c. Manual reset safety.

- d. Thermostat: Devices and wiring are specified in Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
 Thermostat: Single-stage, 24-V ac, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.  
**OR**  
 Thermostat: 2-stage, 24-V ac, wall-mounting type with 50 to 90 deg F (10 to 32 deg C) operating range and fan on switch.  
**OR**  
 Thermostat: Single-stage, 24-V ac type with duct-mounting sensor and 50 to 90 deg F (10 to 32 deg C) operating range.  
**OR**  
 Thermostat: 2-stage, 24-V ac type with duct-mounting sensor and 50 to 90 deg F (10 to 32 deg C) operating range.
- 8. Automatic Fan Thermal Switch: Fan operates with heat-exchanger temperature more than 135 deg F (58 deg C).
- 9. Discharge Louvers: Independently adjustable horizontal blades.
- 10. Accessories:
  - a. Vertical discharge louvers.
  - b. Discharge Nozzle: Discharge at 25 to 65 degrees (0.44 to 1.13 radians) **OR** 50 to 90 degrees (0.87 to 1.57 radians), **as directed**, from horizontal.
  - c. Summer fan switch.
  - d. Unit-mounted thermostat bracket.
  - e. Oil Booster Pump: 30-gph (108-L/h) **OR** 70-gph (252-L/h), **as directed**, capacity; motor and 2-stage fuel unit with pressure-regulating valve and strainer.
  - f. Oil safety valve.
  - g. Outdoor Combustion-Air Adapter: Sealed to housing and fitted with quick access cover or door and fitting for terminating outdoor-air duct.

### 1.3 EXECUTION

#### A. Installation

- 1. Install and connect gas-fired unit heaters and associated fuel and vent features and systems according to NFPA 54 **OR** CAN/CSA B149.1, **as directed**, applicable local codes and regulations, and manufacturer's written installation instructions.
- 2. Install and connect oil-fired unit heaters and associated fuel and vent piping according to NFPA 31 **OR** CAN/CSA B139, **as directed**, applicable local codes and regulations, and manufacturer's written installation instructions.
- 3. Suspended Units: Suspend from substrate using threaded rods, spring hangers, and building attachments. Secure rods to unit hanger attachments. Adjust hangers so unit is level and plumb.
  - a. Restrain the unit to resist code-required horizontal acceleration.
- 4. Substrate-Mounted Units: Provide supports connected to substrate. Secure units to supports.
  - a. Spring hangers and seismic restraints are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - b. Anchor the unit to resist code-required horizontal acceleration.

#### B. Connections

- 1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
- 2. Install piping adjacent to fuel-fired unit heater to allow service and maintenance.
- 3. Gas Piping: Comply with Division 23 Section(s) "Facility Natural-gas Piping" **OR** "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping to gas train inlet; provide union with enough clearance for burner removal and service.



4. Fuel Oil Piping: Comply Division 23 Section "Facility Fuel-oil Piping". Connect to fuel oil supply and return piping with shutoff valve and union at each connection.
  5. Vent Connections: Comply with Division 23 Section "Breechings, Chimneys, And Stacks".
  6. Electrical Connections: Comply with applicable requirements in Division 22.
    - a. Install electrical devices furnished with heaters but not specified to be factory mounted.
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
  2. Tests and Inspections:
    - a. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - b. Verify bearing lubrication.
    - c. Verify proper motor rotation.
    - d. Test Reports: Prepare a written report to record the following:
      - 1) Test procedures used.
      - 2) Test results that comply with requirements.
      - 3) Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
  3. Remove and replace malfunctioning units and retest as specified above.
- D. Adjusting
1. Adjust initial temperature set points.
  2. Adjust burner and other unit components for optimum heating performance and efficiency.
- E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain fuel-fired unit heaters.

END OF SECTION 23 55 33 00

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## SECTION 23 55 33 00a - UNIT HEATERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for unit heaters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Cabinet unit heaters with centrifugal fans and hot-water, steam, and electric-resistance heating coils.
  - b. Propeller unit heaters with hot-water, steam, and electric-resistance heating coils.
  - c. Wall and ceiling heaters with propeller fans and electric-resistance heating coils.

#### C. Definitions

1. BAS: Building automation system.
2. CWP: Cold working pressure.
3. PTFE: Polytetrafluoroethylene plastic.
4. TFE: Tetrafluoroethylene plastic.

#### D. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated.
2. LEED Submittal:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1-2004, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - a. Plans, elevations, sections, and details.
  - b. Location and size of each field connection.
  - c. Details of anchorages and attachments to structure and to supported equipment.
  - d. Equipment schedules to include rated capacities, operating characteristics, furnished specialties, and accessories.
  - e. Location and arrangement of piping valves and specialties.
  - f. Location and arrangement of integral controls.
  - g. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that cabinet unit heaters, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1-2004 Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2004, Section 6 - "Heating, Ventilating, and Air-Conditioning."

## 1.2 PRODUCTS

### A. Cabinet Unit Heaters

1. Description: A factory-assembled and -tested unit complying with ARI 440.
  - a. Comply with UL 2021.
2. Coil Section Insulation (for duct-liner-type, glass-fiber insulation): ASTM C 1071; surfaces exposed to airstream shall be aluminum-foil facing **OR** erosion-resistant coating, **as directed**, to prevent erosion of glass fibers.
  - a. Thickness: **1/2 inch (13 mm) OR 1 inch (25 mm) OR 1-1/2 inches (38 mm), as directed.**
  - b. Thermal Conductivity (k-Value): **0.26 Btu x in./h x sq. ft. at 75 deg F (0.037 W/m x K at 24 deg C)** mean temperature.
  - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
  - d. Adhesive: Comply with ASTM C 916 and with NFPA 90A or NFPA 90B.
  - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Coil Section Insulation (for flexible elastomeric insulation): Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
  - a. Thickness: **3/8 inch (9 mm) OR 1/2 inch (13 mm) OR 3/4 inch (19 mm) OR 1 inch (25 mm), as directed.**
  - b. Thermal Conductivity (k-Value): **0.24 Btu x in./h x sq. ft. at 75 deg F (0.034 W/m x K at 24 deg C)** mean temperature.
  - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
  - d. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
  - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
4. Cabinet (for surface, semi-recessed, and fully recessed units): Steel with factory prime coating, ready for field painting **OR** baked-enamel finish with manufacturer's standard paint, in color selected by the Owner **OR** baked-enamel finish with manufacturer's custom paint, in color selected by the Owner, **as directed**.
  - a. Vertical Unit, Exposed Front Panels: Minimum **0.0528-inch- (1.35-mm-) OR 0.0677-inch- (1.7-mm-), as directed**, thick, galvanized, **as directed**, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
  - b. Horizontal Unit, Exposed Bottom Panels: Minimum **0.0528-inch- (1.35-mm-) OR 0.0677-inch- (1.7-mm-), as directed**, thick, galvanized, **as directed**, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
  - c. Recessing Flanges (for units that are semirecessed or fully recessed in walls or ceilings): Steel, finished to match cabinet.
  - d. Control Access Door: Key operated.
  - e. Base (for surface, vertical, wall-mounting units): Minimum **0.0528-inch- (1.35-mm-)** thick steel, finished to match cabinet, **4 inches (100 mm) OR 6 inches (150 mm), as directed**, high with leveling bolts.
  - f. Extended Piping Compartment: **8-inch- (200-mm-), as directed**, wide piping end pocket.
  - g. False Back (for vertical, wall-mounting units only): Minimum **0.0428-inch- (1.1-mm-)** thick steel, finished to match cabinet.
  - h. Outdoor-Air Wall Box (for vertical, wall-mounting units only): Minimum **0.1265-inch- (3.2-mm-)** thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen. Aluminum louver with anodized **OR** baked-enamel, **as directed**, finish in color selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.
    - 1) Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with manual **OR** electronic **OR** pneumatic, **as directed**, two-position actuators.

5. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
  - a. Washable Foam: 70 percent arrestance and 3 MERV.
  - b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
  - c. Pleated: 90 percent arrestance and 7 MERV.
6. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **200 psig (1378 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain.  
**OR**  
 Steam Coil: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **75 psig (517 kPa)**.  
**OR**  
 Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
7. Fan and Motor Board: Removable.
  - a. Fan: Forward curved, high static, **as directed**, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - b. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
8. Factory, Hot-Water Piping Package: **ASTM B 88, Type L (ASTM B 88M, Type B) OR ASTM B 88, Type M (ASTM B 88M Type C), as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet and outlet.
  - a. Two **OR** Three, **as directed**,-way, two-position **OR** modulating, **as directed**, control valve. Three-way valve packages shall include bypass line with manually adjustable balance device, **as directed**.
  - b. Hose Kits: Minimum **400-psig (2758-kPa)** working pressure, and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
    - 1) Length: **24 inches (600 mm) OR 36 inches (900 mm), as directed**.
    - 2) Minimum Diameter: Equal to cabinet unit heater connection size.
  - c. Two-Piece, Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and **600-psig (4140-kPa)** minimum CWP rating and blowout-proof stem.
  - d. Calibrated-Orifice Balancing Valves: Bronze body, ball type, **125-psig (860-kPa)** working pressure, **250 deg F (121 deg C)** maximum operating temperature; with calibrated orifice or venture, connection for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
  - e. Automatic Flow-Control Valve: Brass or ferrous-metal body, **300-psig (2068-kPa)** working pressure at **250 deg F (121 deg C)**, with removable, corrosion-resistant, tamperproof, self-cleaning, piston-spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
  - f. Y-Pattern, Hot-Water Strainers: Cast-iron body (ASTM A 126, Class B); **125-psig (860-kPa)** minimum working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum **NPS 1/2 (DN 15)** threaded pipe and full-port ball valve in strainer drain connection.
  - g. Wrought-Copper Unions: ASME B16.22.
9. Control devices and operational sequences are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
10. Basic Unit Controls:
  - a. Control voltage transformer.
  - b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
    - 1) Heat-off switch.

- 2) Fan on-auto switch.
  - 3) Manual fan speed switch (for use with multispeed motors).
  - 4) Adjustable deadband.
  - 5) Concealed **OR** Exposed, **as directed**, set point.
  - 6) Concealed **OR** Exposed, **as directed**, indication.
  - 7) **Deg F (Deg C)** indication.
  - c. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
  - d. Unoccupied period override push button.
  - e. Data entry and access port.
    - 1) Input data includes room temperature, and occupied and unoccupied periods.
    - 2) Output data includes room temperature, supply-air temperature, entering-water temperature, operating mode, and status.
  11. DDC, **as directed**, Terminal Controller:
    - a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
    - b. Unoccupied Period Override: Two, **as directed**, hours.
    - c. Unit Supply-Air Fan Operations:
      - 1) Occupied Periods: Fan runs continuously.
      - 2) Unoccupied Periods: Fan cycles to maintain setback room temperature.
    - d. Heating Coil Operations:
      - 1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
      - 2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
    - e. Outdoor-Air Damper Operation:
      - 1) Occupied Periods: Open dampers. Delay damper opening if room temperature is more than three degrees below set point.
      - 2) Unoccupied Periods: Close damper.
    - f. Controller shall have volatile-memory backup.
  12. BAS Interface Requirements:
    - a. Interface relay for scheduled operation.
    - b. Interface relay to provide indication of fault at central workstation.
    - c. Interface shall be BAC-net **OR** LonWorks, **as directed**, compatible for central BAS workstation and include the following functions:
      - 1) Adjust set points.
      - 2) Cabinet unit heater start, stop, and operating status.
      - 3) Data inquiry, including outdoor-air damper position, **as directed**, supply-air and room-air temperature.
      - 4) Occupied and unoccupied schedules.
  13. Electrical Connection: Factory wire motors and controls for a single field connection.
- B. Propeller Unit Heaters
1. Description: An assembly including casing, coil, fan, and motor in vertical **OR** horizontal **OR** vertical and horizontal, **as directed**, discharge configuration with adjustable discharge louvers.
  2. Comply with UL 2021, for electric unit heaters.
  3. Comply with UL 823, for explosion-proof electric unit heaters.
  4. Cabinet: Removable panels for maintenance access to controls.
  5. Cabinet Finish: Manufacturer's standard **OR** custom, **as directed**, baked enamel applied to factory-assembled and -tested propeller unit heater before shipping.
  6. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
  7. Discharge Louver: Adjustable fin diffuser for horizontal units and conical diffuser for vertical units.

8. General Coil Requirements: Test and rate hot-water **OR** steam, **as directed**, propeller unit heater coils according to ASHRAE 33.
9. Hot-Water Coil: Copper tube, minimum **0.025-inch (0.635-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **200 psig (1380 kPa)** and a maximum entering-water temperature of **325 deg F (163 deg C)**, with manual air vent. Test for leaks to **350 psig (2413 kPa)** underwater.  
**OR**  
Hot-Water Coil: Cupronickel tube, minimum **0.031-inch (0.78-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **400 psig (2760 kPa)** and a maximum entering-water temperature of **450 deg F (232 deg C)**, with manual air vent. Test for leaks to **600 psig (4137 kPa)** underwater.  
**OR**  
Hot-Water Coil: Red brass tube, minimum **0.049-inch (1.24-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **260 psig (1793 kPa)** and a maximum entering-water temperature of **390 deg F (199 deg C)**, with manual air vent. Test for leaks to **390 psig (2689 kPa)** underwater.  
**OR**  
Hot-Water Coil: Steel tube, minimum **0.049-inch (1.24-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **400 psig (2760 kPa)** and a maximum entering-water temperature of **450 deg F (232 deg C)**, with manual air vent. Test for leaks to **600 psig (4137 kPa)** underwater.  
**OR**  
Hot-Water Coil: Vertical steel tube, minimum **0.065-inch (1.65-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **400 psig (2760 kPa)** and a maximum entering-water temperature of **450 deg F (232 deg C)**, with steel headers at top and bottom. Test for leaks to **600 psig (4137 kPa)** underwater.  
**OR**  
Steam Coil: Copper tube, minimum **0.025-inch (0.635-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **75 psig (520 kPa)**.  
**OR**  
Steam Coil: Red brass tube, minimum **0.049-inch (1.24-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **75 psig (520 kPa)**.  
**OR**  
Steam Coil: Vertical steel tube, minimum **0.065-inch (1.65-mm)** wall thickness, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)** and rated for a minimum working pressure of **100 psig (690 kPa) OR 200 psig (1380 kPa)**, **as directed**, with steel headers at top and bottom.
10. Electric-Resistance Heating Elements: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than **0.16 inch (4 mm)**. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed **550 deg F (288 deg C)** at any point during normal operation.
  - a. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
  - b. Wiring Terminations: Stainless-steel or corrosion-resistant material.
11. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
12. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Motor Type: Permanently lubricated, explosion proof **OR** multispeed **OR** variable speed, **as directed**.
13. Control Devices:
  - a. Unit-mounted **OR** Wall-mounting, **as directed**, variable, **as directed**, fan-speed switch.
  - b. Unit-mounted **OR** Wall-mounting, **as directed**, thermostat.



## C. Wall And Ceiling Heaters

1. Description: An assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.
2. Cabinet:
  - a. Front Panel: Stamped-steel louver **OR** Extruded-aluminum bar grille, **as directed**, with removable panels fastened with tamperproof fasteners.
  - b. Finish: Baked enamel over baked-on primer with manufacturer's standard **OR** custom, **as directed**, color selected by the Owner, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
  - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.
3. Surface-Mounting Cabinet Enclosure: Steel with finish to match cabinet.
4. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high temperature protection. Provide integral circuit breaker for overcurrent protection, **as directed**.
5. Fan: Aluminum propeller directly connected to motor.
  - a. Motor: Permanently lubricated, multispeed, **as directed**. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
6. Controls: Unit-mounted thermostat. Low-voltage relay with transformer kit, **as directed**.
7. Electrical Connection: Factory wire motors and controls for a single field connection with disconnect switch, **as directed**.

## 1.3 EXECUTION

## A. Installation

1. Install wall boxes in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants".
2. Install cabinet unit heaters to comply with NFPA 90A.
3. Install propeller unit heaters level and plumb.
4. Suspend cabinet unit heaters from structure with elastomeric hangers and seismic restraints, **as directed**. Vibration isolators and seismic restraints, **as directed**, are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Suspend propeller unit heaters from structure with all-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**. Hanger rods and attachments to structure are specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment". Vibration hangers are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install wall-mounting thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify location of thermostats and other exposed control sensors with Drawings and room details before installation.
7. Install new filters in each fan-coil unit within two weeks of Final Completion.

## B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Connect piping to cabinet unit heater's factory, hot-water piping package. Install the piping package if shipped loose.
4. Connect supply and return ducts to cabinet unit heaters with flexible duct connectors specified in Division 23 Section "Air Duct Accessories".
5. Comply with safety requirements in UL 1995.

6. Unless otherwise indicated, install union and gate or ball valve on supply-water connection and union and calibrated balancing valve on return-water connection of unit heater. Hydronic specialties are specified in Division 23 Section "Hydronic Piping".
  7. Unless otherwise indicated, install union and gate or ball valve on steam-supply connection and union, strainer, steam trap, and gate or ball valve on condensate-return connection of unit heater. Steam specialties are specified in Division 23 Section "Steam And Condensate Heating Piping".
  8. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  9. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
    - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    - b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
    - c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
  2. Remove and replace malfunctioning units and retest as specified above.
- D. Adjusting
1. Adjust initial temperature set points.
  2. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters.

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Task	Specification	Specification Description
23 55 33 00	01 22 16 00	No Specification Required

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## SECTION 23 57 13 00 - HEAT EXCHANGERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for hydronic and steam heat exchangers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes shell-and-tube and plate heat exchangers.

#### C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Coordination Drawings: Equipment room, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - a. Tube-removal space.
  - b. Structural members to which heat exchangers will be attached.
3. Manufacturer Seismic Qualification Certification: Submit certification that heat exchanger, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

#### D. Quality Assurance

1. ASME Compliance: Fabricate and label heat exchangers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

### 1.2 PRODUCTS

#### A. Shell-And-Tube Heat Exchangers

1. Configuration: U-tube with removable bundle.
2. Shell Materials: Steel.
3. Head:
  - a. Materials: Cast iron **OR** Cast stainless steel **OR** Fabricated steel **OR** Fabricated steel with removable cover **OR** Fabricated stainless steel **OR** Fabricated stainless steel with removable cover, **as directed**.
  - b. Flanged and bolted to shell.
4. Tube:
  - a. Seamless copper **OR** Steel **OR** Stainless-steel **OR** Cupronickel **OR** Admiralty-metal, **as directed**, tubes.
  - b. Tube diameter is determined by manufacturer based on service.
5. Tubesheet Materials: Steel **OR** Stainless-steel, **as directed**, tubesheets.
6. Baffles: Steel **OR** Stainless steel, **as directed**.
7. Piping Connections:
  - a. Shell: Flanged inlet and threaded **OR** Threaded inlet and **OR** Flanged inlet and, **as directed**, outlet fluid connections, threaded drain, and vent connections.
  - b. Head: Threaded **OR** Flanged, **as directed**, inlet and outlet fluid connections.
8. Support Saddles:
  - a. Fabricated of material similar to shell.
  - b. Foot mount with provision for anchoring to support.

- c. Fabricate attachment of saddle supports to pressure vessel with reinforcement strong enough to resist heat-exchanger movement during a seismic event when heat-exchanger saddles are anchored to building structure.

B. Gasketed Plate Heat Exchangers

1. Configuration: Freestanding assembly consisting of frame support, top and bottom carrying and guide bars, fixed and movable end plates, tie rods, individually removable plates, and one-piece gaskets.
2. Frame:
  - a. Capacity to accommodate 20 percent additional plates.
  - b. Painted carbon steel with provisions for anchoring to support.
3. Top and Bottom Carrying and Guide Bars: Painted carbon steel, aluminum, or stainless steel.
  - a. Fabricate attachment of heat-exchanger carrying and guide bars with reinforcement strong enough to resist heat-exchanger movement during a seismic event when heat-exchanger carrying and guide bars are anchored to building structure.
4. End-Plate Material: Painted carbon steel.
5. Tie Rods and Nuts: Steel or stainless steel.
6. Plate Material: 0.024 inch (0.6 mm) OR 0.031 inch (0.8 mm) OR 0.039 inch (1 mm), as directed, thick before stamping; Type 304 OR 304L OR 316 OR 316L, as directed, stainless steel.
7. Gasket Material: Nitrile rubber OR EPDM, as directed.
8. Piping Connections:
  - a. Threaded port for NPS 2 (DN 50) and smaller. For larger sizes, furnish end-plate port with threaded studs suitable for flanged connection.
  - b. End plate with welded carbon-steel nozzles. Threaded pipe connection for NPS 2 (DN 50) and smaller; carbon-steel flanged pipe connection for larger sizes.
  - c. Line wetted surfaces with same material as plates.
9. Enclose plates in a solid aluminum OR stainless-steel, as directed, removable shroud.

C. Brazed Plate Heat Exchangers

1. Configuration: Brazed assembly consisting of two end plates, one with threaded nozzles and pattern-embossed plates.
2. End-Plate Material: Type 316 stainless steel.
3. Threaded Nozzles: Type 316 stainless steel.
4. Plate Material: Type 316 stainless steel.
5. Brazing Material: Copper or nickel.

### 1.3 EXECUTION

A. Heat-Exchanger Installation

1. Install shell-and-tube heat exchangers on saddle supports.
2. Install shell-and-tube heat exchangers on, and anchor to, concrete base.

B. Connections

1. Install shutoff valves at heat-exchanger inlet and outlet connections.
2. Install relief valves on heat-exchanger heated-fluid connection and install pipe relief valves, full size of valve connection, to floor drain.
3. Install vacuum breaker at heat-exchanger steam inlet connection.
4. Install hose end valve to drain shell.

END OF SECTION 23 57 13 00





Task	Specification	Specification Description
23 57 16 00	23 57 13 00	Heat Exchangers
23 57 19 13	23 57 13 00	Heat Exchangers
23 57 19 19	23 57 13 00	Heat Exchangers
23 57 19 23	23 57 13 00	Heat Exchangers

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## SECTION 23 61 16 00 - CENTRIFUGAL WATER CHILLERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for centrifugal water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Packaged, water-cooled, electric-motor-driven centrifugal chillers.
  - b. Packaged, portable refrigerant recovery units.
  - c. Heat-exchanger, brush-cleaning system.

#### C. Definitions

1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
4. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
5. **kW/Ton (kW/kW)**: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in **tons (kW)** at any given set of rating conditions.
6. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

#### D. Performance Requirements

1. Seismic Performance: Centrifugal chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
  - a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of **60 deg F (16 deg C) OR 55 deg F (13 deg C) OR 40 deg F (4 deg C), as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
  - b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of **65 deg F (18 deg C) OR 60 deg F (16 deg C) OR 55 deg F (13 deg C), as directed**.
  - c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 550/590, **as directed**:
  - a. Allowable Capacity Tolerance: Zero percent.
  - b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

#### E. Submittals



1. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Startup service reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

F. Quality Assurance

1. ARI Certification: Certify chiller according to ARI 550 certification program.
2. ARI Rating: Rate chiller performance according to requirements in ARI 550/590.
3. ASHRAE Compliance:
  - a. ASHRAE 15 for safety code for mechanical refrigeration.
  - b. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
4. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
5. ASME Compliance: Fabricate and label chillers to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, as applicable to chiller design. For chillers charged with R-134a refrigerant, include an ASME U-stamp and nameplate certifying compliance.
6. Comply with NFPA 70.
7. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.
8. Green Seal Compliance: Signed by manufacturer **OR** Green Seal, **as directed**, certifying compliance with GS-31.

G. Delivery, Storage, And Handling

1. Ship chillers from the factory fully charged with refrigerant.  
**OR**  
Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
2. Ship each oil-lubricated chiller with a full charge of oil.
  - a. Ship oil factory installed in chiller **OR** in containers separate from chiller, **as directed**.
3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
    - a. Extended warranties include, but are not limited to, the following:
      - 1) Complete chiller including refrigerant and oil charge.
- OR**

- Complete compressor and drive assembly including refrigerant and oil charge.  
**OR**  
Refrigerant **OR** Refrigerant and oil, **as directed**, charge.
- 2) Parts only **OR** Parts and labor, **as directed**.
  - 3) Loss of refrigerant charge for any reason.
- b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Final Completion.

## 1.2 PRODUCTS

### A. Manufactured Unit

1. Description: Factory-assembled and -tested chiller complete with compressor, compressor motor, compressor motor controller, evaporator **OR** lubrication system evaporator, **as directed**, condenser, heat-reclaim condenser as indicated, controls, interconnecting unit piping and wiring, and indicated accessories.
  - a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
  - b. For chillers with dual compressors, provide each compressor with a dedicated motor and motor controller, and provide for continued operation when either compressor-drive assembly fails or is being serviced.
2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.

### B. Compressor-Drive Assembly

1. Description: Single-stage or multistage, variable-displacement, centrifugal-type compressor driven by an electric motor.
  - a. Where indicated, provide oil-free compressor technology using a permanent magnet synchronous motor, magnetic bearings, integral variable frequency controller, and digital electronic controls.
2. Compressor:
  - a. Casing: Cast iron, precision ground.
  - b. Impeller: High-strength cast aluminum or cast-aluminum alloy on carbon- or alloy-steel shaft.
3. Drive: Direct-drive, hermetic **OR** Gear-drive, hermetic **OR** Gear-drive, open **OR** Direct- or gear-drive, hermetic **OR** Direct- or gear-drive, open or hermetic, **as directed**, design using an electric motor as the driver.
  - a. Gear Drives: For chillers with gear drives, provide single- or double-helical gear design continuously coated with oil while chiller is operating. Gears shall comply with American Gear Manufacturer Association standards.
  - b. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
  - c. Seals: Seal drive assembly to prevent refrigerant leakage.
4. Compressor Motor:
  - a. Continuous-duty, squirrel-cage, induction-type, two-pole motor with energy efficiency required to suit chiller energy efficiency indicated.
  - b. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
  - c. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
  - d. For chillers with open drives, provide motor with open-dripproof **OR** weather-protected, Type I **OR** weather-protected, Type II **OR** totally enclosed, **as directed**, enclosure.
  - e. Provide motor with thermistor or RTD in single motor winding **OR** each of three-phase motor windings, **as directed**, to monitor temperature and report information to chiller control panel.



- f. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
- g. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
- 5. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
  - a. Overspeed Test: 25 percent above design operating speed.
- 6. Service: Easily accessible for inspection and service.
  - a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
  - b. Provide lifting lugs or eyebolts attached to casing.
- 7. Economizers: For multistage chillers, provide interstage economizers.
- 8. Capacity Control: Modulating, variable-inlet, guide-vane assembly combined with hot-gas bypass, if necessary, to achieve performance indicated.
  - a. Maintain stable operation that is free of surge, cavitation, and vibration throughout range of operation. Configure to achieve most energy-efficient operation possible.
  - b. Operating Range: From 100 to 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
  - c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of **2.5 deg F (1.4 deg C)** for each 10 percent in capacity reduction, **as directed**.
  - d. Chillers with variable frequency controllers shall modulate compressor speed with variable-inlet, guide-vane control to achieve optimum energy efficiency.
- 9. Oil Lubrication System: Consisting of pump, filtration, heater, **as directed**, cooler, factory-wired power connection, and controls.
  - a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, coastdown, and standby conditions including power failure.
  - b. Manufacturer's standard method **OR** Thermostatically controlled oil heater properly sized, **as directed**, to remove refrigerant from oil.
  - c. Oil filter **OR** Dual oil filters, one redundant, **as directed**, shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
  - d. Refrigerant **OR** Water, **as directed**, -cooled oil cooler.
  - e. Factory-installed and pressure-tested piping with isolation valves and accessories.
  - f. Oil compatible with refrigerant and chiller components.
  - g. Positive visual indication of oil level.

#### C. Refrigeration

- 1. Refrigerant:
  - a. Type: R-123; ASHRAE 34, Class B1 **OR** R-134a; ASHRAE 34, Class A1, as directed.
  - b. Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
- 2. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
- 3. Pressure Relief Device:
  - a. Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  - b. For Chillers Using R-123: Rupture disc constructed of frangible carbon **OR** Spring-loaded, pressure relief valve; single- or multiple-reseating type, **as directed**.
  - c. For Chillers Using R-134a: ASME-rated, spring-loaded, pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.

4. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.
  5. Refrigerant Isolation for Chillers Using R-134a: Factory install positive shutoff, manual, **as directed**, isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell, **as directed**.
  6. Purge System:
    - a. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic purge system for collection and return of refrigerant and lubricating oil and for removal of noncondensables including, but not limited to, water, water vapor, and noncondensable gases.
    - b. System shall be a thermal purge design, refrigerant or air cooled, equipped with a carbon filter that includes an automatic regeneration cycle.
    - c. Factory wire to chiller's main power supply and system complete with controls, piping, and refrigerant valves to isolate the purge system from the chiller.
    - d. Construct components of noncorrodible materials.
    - e. Controls shall interface with chiller control panel to indicate modes of operation, set points, data reports, diagnostics, and alarms.
    - f. Efficiency of not more than **0.02 lb of refrigerant per pound of air (9 g of refrigerant per gram of air)** when rated according to ARI 580.
    - g. Operation independent of chiller per ASHRAE 147.
  7. Positive-Pressure System:
    - a. For chillers operating at subatmospheric pressures (using R-123 refrigerant), factory install an automatic positive-pressure system.
    - b. During nonoperational periods, positive-pressure system shall automatically maintain a positive pressure for atmosphere in the refrigerant pressure vessel of not less than **0.5 psig (3 kPa)** (adjustable) up to a pressure that remains within the vessel design pressure limits.
    - c. System shall be factory wired and include controller, electric heat, pressure transmitter, or switch.
- D. Evaporator
1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
  2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
  3. Designed to prevent liquid refrigerant carryover from entering compressor.
  4. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
  5. Tubes:
    - a. Individually replaceable from either end and without damage to tube sheets and other tubes.
    - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
    - c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
    - d. Nominal OD: Manufacturer's choice **OR** **3/4 inch (19 mm)** **OR** **1 inch (25 mm)**, **as directed**.
    - e. Minimum Wall Thickness: Manufacturer's choice **OR** **0.025 inch (0.6 mm)** **OR** **0.028 inch (0.7 mm)** **OR** **0.035 inch (0.9 mm)**, **as directed**.
    - f. External Finish: Manufacturer's standard.
    - g. Internal Finish: Enhanced **OR** Smooth, **as directed**.
  6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
  7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.



8. Water Box:
  - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
  - c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
  - d. Hinged **OR** Davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** Davited, **as directed**, marine water-box covers.
  - e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - f. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - g. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
9. Additional Corrosion Protection:
  - a. Electrolytic corrosion-inhibitor anode.
  - b. Coat wetted surfaces with a corrosion-resistant finish.  
**OR**  
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

#### E. Condenser

1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.
2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
4. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
5. Tubes:
  - a. Individually replaceable from either end and without damage to tube sheets and other tubes.
  - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
  - c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
  - d. Nominal OD: Manufacturer's choice **OR 3/4 inch (19 mm) OR 1 inch (25 mm)**, **as directed**
  - e. Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.
  - f. External Finish: Manufacturer's standard.
  - g. Internal Finish: Enhanced **OR** Smooth, **as directed**.
6. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
7. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
8. Water Box:
  - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
  - c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
  - d. Hinged **OR** Davited, **as directed**, water boxes.  
**OR**

- Hinged **OR** Davited, **as directed**, marine water-box covers.
- e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - f. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - g. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
9. Additional Corrosion Protection:
- a. Electrolytic corrosion-inhibitor anode.
  - b. Coat wetted surfaces with a corrosion-resistant finish.
- OR**  
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
- F. Heat-Reclaim Condenser
1. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.
  2. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
  3. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
  4. Tubes:
    - a. Individually replaceable from either end and without damage to tube sheets and other tubes.
    - b. Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
    - c. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
    - d. Nominal OD: Manufacturer's choice **OR 3/4 inch (19 mm) OR 1 inch (25 mm)**, **as directed**.
    - e. Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.
    - f. External Finish: Manufacturer's standard.
    - g. Internal Finish: Enhanced **OR** Smooth, **as directed**.
  5. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
  6. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
  7. Water Box:
    - a. Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
    - b. Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
    - c. Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
    - d. Hinged **OR** Davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** Davited, **as directed**, marine water-box covers.
    - e. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
    - f. Thermistor or RTD temperature sensor factory installed in each nozzle.
    - g. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
  8. Additional Corrosion Protection:
    - a. Electrolytic corrosion-inhibitor anode.
    - b. Coat wetted surfaces with a corrosion-resistant finish.

**OR**



Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

G. Insulation

1. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
  - a. Thickness: **3/4 inch (19 mm) OR 1-1/2 inches (38 mm), as directed.**
2. Adhesive: As recommended by insulation manufacturer.
3. Factory-applied insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
  - a. Apply adhesive to 100 percent of insulation contact surface.
  - b. Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
  - c. Seal seams and joints to provide a vapor barrier.
  - d. After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.

H. Electrical

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
  - a. Branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
    - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
  - b. NEMA ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
  - c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Factory-installed wiring outside of enclosures shall be in metal raceway except make terminal connections with not more than a **24-inch (610-mm)** length of liquidtight **OR** flexible metallic, **as directed**, conduit.
5. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at all operating conditions.
  - a. If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
  - b. Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAR ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
  - c. Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within one minute after de-energizing.
  - d. Provide a ground terminal and a terminal block or individual connectors for phase connection.

I. Motor Controller

1. Enclosure: Factory installed, unit mounted **OR** Factory furnished, field mounted, **as directed**, NEMA 250 **OR** NEMA ICS 6, **as directed**, Type 1 **OR** Type 4 **OR** Type 4X **OR** Type 12, **as directed**, with hinged full-front access door with lock and key or padlock and key, **as directed**.
2. Control Circuit: Obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected control devices.
3. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.
4. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
5. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
6. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.
7. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
  - a. Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  - b. Visual indication of motor and control status, including the following conditions:
    - 1) Controller on.
    - 2) Overload trip.
    - 3) Loss of phase.
    - 4) Starter fault.
8. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
  - a. Externally Operated, Door-Interlocked, **as directed**, Disconnect: Fused disconnect switch **OR** Nonfused disconnect switch **OR** Circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
  - b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
  - c. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
  - d. Control Relays: Time-delay relays.
  - e. Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
  - f. Number-of-Starts Counter: Numerical readout on face of enclosure.
  - g. Meters: Panel type, 2-1/2 inches (64 mm) **OR** 4-1/4 inches (108 mm), **as directed**, with 90 **OR** 120 **OR** 270, **as directed**,-degree scale and 1 **OR** 2, **as directed**, percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
    - 1) Ammeter: Output current for each phase, with current sensors rated to suit application.
    - 2) Voltmeter: Output voltage for each phase.
    - 3) Frequency Meter, **as directed**: Output frequency.
    - 4) Real-time clock with current time and date.
    - 5) Total run time.

**OR**

Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

  - 1) Selectable, digital display of the following:
    - a) Phase Currents, Each Phase: Plus or minus 1 percent.
    - b) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    - c) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    - d) Three-Phase Real Power: Plus or minus 2 percent.
    - e) Three-Phase Reactive Power: Plus or minus 2 percent.
    - f) Power Factor: Plus or minus 2 percent.
    - g) Frequency: Plus or minus 0.5 percent.
    - h) Integrated Demand with Demand Interval Selectable from Five to 60 Minutes: Plus or minus 2 percent.



- i) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
  - 2) Mounting: Display and control unit flush or semirecessed in instrument compartment door.
- h. Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
- i. Power Protection: Chiller shall shut down within six cycles of power interruption.

J. Variable Frequency Controller

1. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
2. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
3. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, with hinged full-front access door with lock and key.
4. Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
5. Technology: Pulse width modulated (PWM) output with insulated gate bipolar transistors (IGBT); suitable for variable torque loads.
6. Controller shall consist of a rectifier converter section, a digital/analog driver regulator section, and an inverter output section.
  - a. Rectifier section shall be a full-wave diode bridge that changes fixed-voltage, fixed-frequency, ac line power to a fixed dc voltage. Silicon controller rectifiers, current source inverters, and paralleling of devices are unacceptable. Rectifier shall be insensitive to phase rotation of the ac line.
  - b. Regulator shall provide full digital control of frequency and voltage.
  - c. Inverter section shall change fixed dc voltage to variable-frequency, variable ac voltage, for application to a squirrel-cage motor. Inverter shall produce a sine-coded, pulse width modulated (PWM) output wave form and shall conduct no radio-frequency interference back to the input power supply.
7. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
8. Operating Requirements:
  - a. Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum, **as directed**.
  - b. Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
  - c. Capable of driving full load, without derating, under the following conditions:
    - 1) Ambient Temperature: 0 to 50 deg C.
    - 2) Relative Humidity: Up to 90 **OR** 95, **as directed**, percent (noncondensing).
    - 3) Altitude: **3300 feet (1005 m) OR 6600 feet (2010 m), as directed**.
  - d. Minimum Efficiency: 96 percent at 60 Hz, full load.
  - e. Minimum Displacement Primary-Side Power Factor: 95 percent without harmonic filter, 98 percent with harmonic filter.
  - f. Overload Capability: 1.05 times the full-load current for 7 seconds.
  - g. Starting Torque: As required by compressor-drive assembly.
  - h. Speed Regulation: Plus or minus 1 percent.
  - i. Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
  - j. To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
  - k. Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
9. Internal Adjustability Capabilities:
  - a. Minimum Output Frequency: 6 Hz.
  - b. Maximum Output Frequency: 60 Hz.
  - c. Acceleration: 2 seconds to a minimum of 60 seconds.



- d. Deceleration: 2 seconds to a minimum of 60 seconds.
  - e. Current Limit: 30 percent to a minimum of 100 percent of maximum rating.
  - 10. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
    - a. Overtemperature.
    - b. Short circuit at controller output.
    - c. Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
    - d. Open circuit at controller output.
    - e. Input undervoltage.
    - f. Input overvoltage.
    - g. Loss of input phase.
    - h. Reverse phase.
    - i. AC line switching transients.
    - j. Instantaneous overload, line to line or line to ground.
    - k. Sustained overload exceeding 100 percent of controller rated current.
    - l. Starting a rotating motor.
  - 11. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
  - 12. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss and overvoltage and undervoltage trips.
  - 13. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:
    - a. Power on.
    - b. Run.
    - c. Overvoltage.
    - d. Line fault.
    - e. Overcurrent.
    - f. External fault.
    - g. Motor speed (percent).
    - h. Fault or alarm status (code).
    - i. DC-link voltage.
    - j. Motor output voltage.
    - k. Input kilovolt amperes.
    - l. Total power factor.
    - m. Input kilowatts.
    - n. Input kilowatt-hours.
    - o. Three-phase input voltage.
    - p. Three-phase output voltage.
    - q. Three-phase input current.
    - r. Three-phase output current.
    - s. Three-phase input voltage total harmonic distortion.
    - t. Three-phase input current total harmonic distortion.
    - u. Output frequency (Hertz).
    - v. Elapsed operating time (hours).
    - w. Diagnostic and service parameters.
  - 14. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
  - 15. Control Signal Interface:
    - a. Electric Input Signal Interface: A minimum of two analog inputs (0 to 10 V or 0/4-20 mA) and six programmable digital inputs.
  - 16. Active Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.
- OR**
- Input Line Conditioning: **<Insert requirements>.**

17. Cooling: Air **OR** Refrigerant **OR** Water, **as directed**, cooled.
18. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
  - a. Control Relays: Auxiliary and adjustable time-delay relays.
19. Chiller Capacity Control Interface: Equip chiller with adaptive control logic to automatically adjust the compressor motor speed and the compressor pre-rotation inlet vane position independently to achieve maximum part-load efficiency in response to sensor inputs that are integral to the chiller controls.

K. Controls

1. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
2. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.
3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:
  - a. Date and time.
  - b. Operating or alarm status.
  - c. Fault history with not less than last 10 faults displayed.
  - d. Set points of controllable parameters.
  - e. Trend data.
  - f. Operating hours.
  - g. Number of chiller starts.
  - h. Outdoor-air temperature or space temperature if required for chilled-water reset.
  - i. Entering- and leaving-fluid temperatures of evaporator and condenser.
  - j. Difference in fluid temperatures of evaporator and condenser.
  - k. Fluid flow of evaporator and condenser.
  - l. Fluid pressure drop of evaporator and condenser.
  - m. Refrigerant pressures in evaporator and condenser.
  - n. Refrigerant saturation temperature in evaporator and condenser shell.
  - o. Compressor refrigerant suction and discharge temperature.
  - p. Compressor bearing temperature.
  - q. Motor bearing temperature.
  - r. Motor winding temperature.
  - s. Oil temperature.
  - t. Oil discharge pressure.
  - u. Phase current.
  - v. Percent of motor rated load amperage.
  - w. Phase voltage.
  - x. Demand power (kilowatts).
  - y. Energy use (kilowatt-hours).
  - z. Power factor.
  - aa. For chillers equipped with variable frequency controllers and harmonic filters, include the following:
    - 1) Output voltage and frequency.
    - 2) Voltage total harmonic distortion for each phase.
    - 3) Supply current total demand distortion for each phase.
    - 4) Inlet vane position.
    - 5) Controller internal ambient temperature.
    - 6) Heatsink temperature.
  - bb. Purge suction temperature if purge system is provided.
  - cc. Purge elapsed time if purge system is provided.
4. Control Functions:
  - a. Manual or automatic startup and shutdown time schedule.



- b. Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
    - c. Current limit and demand limit.
    - d. Condenser-fluid temperature.
    - e. External chiller emergency stop.
    - f. Variable evaporator flow.
    - g. Thermal storage.
    - h. Heat reclaim.
  - 5. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
    - a. Low evaporator pressure **OR** temperature, **as directed**; high condenser pressure.
    - b. Low evaporator fluid temperature.
    - c. Low oil differential pressure.
    - d. High or low oil pressure.
    - e. High oil temperature.
    - f. High compressor-discharge temperature.
    - g. Loss of condenser-fluid flow.
    - h. Loss of evaporator fluid flow.
    - i. Motor overcurrent.
    - j. Motor overvoltage.
    - k. Motor undervoltage.
    - l. Motor phase reversal.
    - m. Motor phase failure.
    - n. Sensor- or detection-circuit fault.
    - o. Processor communication loss.
    - p. Motor controller fault.
    - q. Extended compressor surge.
    - r. Excessive air-leakage detection for chillers using R-123 refrigerant.
  - 6. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
  - 7. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
  - 8. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
  - 9. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.
  - 10. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
    - a. Hardwired Points:
      - 1) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours) **OR** power factor, **as directed**.
      - 2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
    - b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.
- L. Finish
- 1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:



- a. Provide at least one coat of primer with a total dry film thickness of at least **2 mils** (0.05 mm).
  - b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least **4 mils** (0.10 mm).
  - c. Paint surfaces that are to be insulated before applying the insulation.
  - d. Paint installed insulation to match adjacent uninsulated surfaces.
  - e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner, **as directed**.
2. Provide the Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

#### M. Accessories

##### 1. Flow Switches:

- a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and verify field-mounting location before installation.
- b. Paddle Flow Switches:
  - 1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
  - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
  - 3) Pressure rating equal to pressure rating of heat exchanger.
  - 4) Construct body and wetted parts of Type 316 stainless steel.
  - 5) House switch in a NEMA 250, Type 4, **as directed**, enclosure constructed of die-cast aluminum.
  - 6) Vane length to suit installation.

**OR**

Pressure Differential Switches:

- 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
  - 2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
  - 3) Set Point: Screw type, field adjustable.
  - 4) Electrical Connections: Internally mounted screw-type terminal blocks.
  - 5) Switch Enclosure: NEMA 250, Type 4, **as directed**.
  - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
2. Vibration Isolation:
    - a. Chiller manufacturer shall furnish vibration isolation for each chiller.
    - b. Neoprene Pad:
      - 1) Two layers of **0.375-inch-** (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
      - 2) Fabricate pads from 40- to 50-durometer neoprene.
      - 3) Provide stainless-steel square bearing plate to load the pad uniformly between **20 and 40 psig** (138 and 276 kPa) with a **0.12- to 0.16-inch** (3- to 4-mm) deflection.

**OR**

Spring Isolator:

- 1) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed so that the Kx/Ky ratio shall be 1.0 or more for stability.
- 2) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
- 3) Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of **0.25 inch** (6 mm) shall be bonded to the baseplate.

- 4) Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
      - 5) Isolators shall be selected for a nominal **1-inch (25-mm) OR 2-inch (50-mm), as directed**, deflection.
    3. Sound Barrier:
      - a. Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
      - b. Provide for repeated installation and removal without use of tape or caulk.
      - c. Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
      - d. Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
      - e. Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
      - f. Continuously lap all exposed seams at least **2 inches (50 mm)** for better sound containment.
      - g. Permanently label each section of cover to indicate its location, description, size, and number sequence.
      - h. Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.
  - N. Packaged Refrigerant Recovery Units
    1. Packaged portable unit consisting of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.
  - O. Heat-Exchanger, Brush-Cleaning System
    1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.
    2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
    3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
    4. Components:
      - a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed **0.025 inch (0.6 mm)**.
      - b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
      - c. Four-Way Valve:
        - 1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
        - 2) Configure valve with parallel flow connections to minimize field installation piping.
        - 3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
        - 4) Pipe connections shall be flanged.

- 5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
- 6) Hydrostatically test to 1.5 times the design working pressure.
- 7) Design the valve to cause no more than **0.5-psig (3-kPa)** pressure drop at design flow conditions.
- 8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
- 9) Valve Actuator: Mount electric actuator to operate valve.  
**OR**  
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
- 10) Position Switches: Factory mount microswitches on the valve to indicate the complete turn of valve in both normal and reverse flow.
- d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
  - 1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
  - 2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
  - 3) Manual override of preset cleaning cycle.
  - 4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
  - 5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
  - 6) Flow switch bypass.
  - 7) Unloading signal to chiller.

P. Source Quality Control

1. Perform functional **OR** functional run, **as directed**, tests of chillers before shipping.
2. Factory performance test chillers, before shipping, according to ARI 550/590.
  - a. Test the following conditions:
    - 1) Design conditions indicated.
    - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.  
**OR**  
Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in **5 deg F (3 deg C)** increments.  
**OR**  
At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
  - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
  - c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
3. Factory sound test chillers, before shipping, according to ARI 575, **s directed**.
  - a. Test the following conditions:
    - 1) Design conditions indicated.
    - 2) Chiller operating at calculated worst-case sound condition.
    - 3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
  - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
  - c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

4. For chillers using R-134a refrigerant, factory test and inspect evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
5. For chillers using R-123 refrigerant, factory test and inspect evaporator and condenser **OR** condenser and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test fluid side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Pressure proof test refrigerant side of heat exchangers to a minimum of **45 psig (310 kPa)**. Vacuum and pressure test for leaks.
6. For chillers located indoors, rate sound power level according to ARI 575.

### 1.3 EXECUTION

#### A. Chiller Installation

1. Install chillers on support structure indicated.
2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1/2 inch (13 mm) OR 1 inch (25 mm) OR 2 inches (50 mm), as directed.**
  - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install chiller using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1/2 inch (13 mm) OR 1 inch (25 mm) OR 2 inches (50 mm), as directed.**
4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
5. Maintain manufacturer's recommended clearances for service and maintenance.
6. Charge chiller with refrigerant and fill with oil if not factory installed.
7. Install separate devices furnished by manufacturer and not factory installed.

#### B. Heat-Exchanger, Brush-Cleaning System Installation

1. Install brush-cleaning system control panel adjacent to chiller control panel.
2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
3. Provide field electric power, as required, to each system control panel and electric actuated valve.
4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.



5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

C. Connections

1. Comply with requirements for piping specified in Division 23 Section(s) "Hydronic Piping" AND "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to chiller to allow service and maintenance.
3. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
4. Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
5. Heat-Reclaim Condenser-Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping **OR** separate vent piping for each chiller, **as directed** to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
7. For chillers equipped with a purge system, extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15 and ASHRAE 147.
8. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
  - a. Complete installation and startup checks according to manufacturer's written instructions.
  - b. Verify that refrigerant charge is sufficient and chiller has been leak tested.
  - c. Verify that pumps are installed and functional.
  - d. Verify that thermometers and gages are installed.
  - e. Operate chiller for run-in period.
  - f. Check bearing lubrication and oil levels.
  - g. Verify that refrigerant pressure relief device is vented outside.
  - h. Verify proper motor rotation.
  - i. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
  - j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**.
  - k. Verify and record performance of chiller protection devices.
  - l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.



3. Prepare test and inspection startup reports.

END OF SECTION 23 61 16 00

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## SECTION 23 61 16 00a - ROTARY-SCREW WATER CHILLERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for rotary screw water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Packaged, water-cooled, single-compressor chillers.
  - b. Packaged, water-cooled, multiple-compressor chillers.
  - c. Packaged, air-cooled chillers.
  - d. Packaged, portable refrigerant recovery units.
  - e. Heat-exchanger, brush-cleaning system.

#### C. Definitions

1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
4. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
5. **kW/Ton (kW/kW)**: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in **tons (kW)** at any given set of rating conditions.
6. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than ARI standard rating conditions.

#### D. Performance Requirements

1. Seismic Performance: Chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
  - a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of **60 deg F (16 deg C) OR 55 deg F (13 deg C) OR 40 deg F (4 deg C)**, **as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
  - b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of **65 deg F (18 deg C) OR 60 deg F (16 deg C) OR 55 deg F (13 deg C)**, **as directed**.
  - c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 550/590, **as directed**:
  - a. Allowable Capacity Tolerance: Zero percent.
  - b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.



## E. Submittals

1. Product Data: For each type of product indicated. Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
6. Startup service reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

## F. Quality Assurance

1. ARI Certification: Certify chiller according to ARI 550 and ARI 590, **as directed**, certification program(s).
2. ARI Rating: Rate chiller performance according to requirements in ARI 550/590.
3. ASHRAE Compliance:
  - a. ASHRAE 15 for safety code for mechanical refrigeration.
  - b. ASHRAE 147 for refrigerant leaks, recovery, and handling and storage requirements.
4. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
5. ASME Compliance: Fabricate and label chiller to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and include an ASME U-stamp and nameplate certifying compliance.
6. Comply with NFPA 70.
7. Comply with requirements of UL and UL Canada and include label by a qualified testing agency showing compliance.

## G. Delivery, Storage, And Handling

1. Ship chillers from the factory fully charged with refrigerant.  
**OR**  
Ship each chiller with a full charge of refrigerant. Charge each chiller with nitrogen if refrigerant is shipped in containers separate from chiller.
2. Ship each oil-lubricated chiller with a full charge of oil.
  - a. Ship oil factory installed in chiller **OR** in containers separate from chiller, **as directed**.
3. Package chiller for export shipping in totally enclosed crate and bagging, **as directed**.

## H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
  - a. Extended warranties include, but are not limited to, the following:
    - 1) Complete chiller including refrigerant and oil charge.  
**OR**  
Complete compressor and drive assembly including refrigerant and oil charge.  
**OR**  
Refrigerant **OR** Refrigerant and oil charge, **as directed**.
    - 2) Parts only **OR** Parts and labor, **as directed**.
    - 3) Loss of refrigerant charge for any reason.
  - b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Final Completion.

## 1.2 PRODUCTS

### A. Packaged, Water-Cooled, Single-Compressor Chillers

1. Description: Factory-assembled and factory-tested **OR** run-tested, **as directed**, chiller with compressor, compressor motor, compressor motor controller, lubrication system, evaporator, condenser, heat-reclaim condenser as indicated, controls, interconnecting unit piping and wiring, and indicated accessories.
  - a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
3. Compressor:
  - a. Description: Hermetic **OR** Open, **as directed**, positive displacement, and oil lubricated.
  - b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
  - c. Rotors: Manufacturer's standard one-, two-, or three-rotor design.
  - d. Drive Coupling: For chillers with open drives, provide flexible disc with all-metal construction and no wearing parts to ensure long life without the need for lubrication.
  - e. Seals: Seal drive assembly to prevent refrigerant leakage.
4. Compressor Motor:
  - a. Continuous-duty, squirrel-cage, induction-type motor with energy efficiency required to suit chiller energy efficiency indicated.
  - b. Factory mounted, aligned, and balanced as part of compressor assembly before shipping.
  - c. Motor shall be of sufficient capacity to drive compressor throughout entire operating range without overload and with sufficient capacity to start and accelerate compressor without damage.
  - d. For chillers with open drives, provide motor with open-dripproof **OR** weather-protected, Type I **OR** weather-protected, Type II **OR** totally enclosed, **as directed**, enclosure.
  - e. Provide motor with thermistor or RTD in single motor winding **OR** each of three-phase motor windings, **as directed**, to monitor temperature and report information to chiller control panel.
  - f. Provide motor with thermistor or RTD to monitor bearing temperature and report information to chiller control panel.
  - g. Provide open-drive motor with internal electric heater, internally powered from chiller power supply.
5. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
  - a. Overspeed Test: 25 percent above design operating speed.
6. Service: Easily accessible for inspection and service.
  - a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
  - b. Provide lifting lugs or eyebolts attached to casing.
7. Capacity Control: Modulating slide-valve assembly or port unloaders combined with a variable frequency controller, if applicable, and hot-gas bypass, if necessary, to achieve performance indicated.
  - a. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
  - b. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
  - c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of 2.5 deg F **1.4 deg C** drop for each 10 percent in capacity reduction, **as directed**.
8. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
  - a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
  - b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.



- c. Oil filter **OR** Dual oil filters, one redundant, **as directed**, shall be the easily replaceable cartridge type, minimum 0.5-micron efficiency, with means of positive isolation while servicing.
- d. Refrigerant **OR** Water, **as directed**, -cooled oil cooler.
- e. Factory-installed and pressure-tested piping with isolation valves and accessories.
- f. Oil compatible with refrigerant and chiller components.
- g. Positive visual indication of oil level.
- 9. Refrigerant Circuit:
  - a. Refrigerant: Type as indicated on Drawings.  
**OR**  
Refrigerant Type: R-134a **OR** HFC, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
  - b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - c. Refrigerant Flow Control: Manufacturer's standard refrigerant flow-control device satisfying performance requirements indicated.
  - d. Pressure Relief Device:
    - 1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - 2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type. Pressure relief valve(s) shall be provided for each heat exchanger. Condenser shall have dual valves with one being redundant and configured to allow either valve to be replaced without loss of refrigerant.
  - e. Refrigeration Transfer: Provide service valves and other factory-installed accessories required to facilitate transfer of refrigerant from chiller to a remote refrigerant storage and recycling system. Comply with requirements in ASHRAE 15 and ASHRAE 147.
  - f. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell. In addition, provide isolation valve on suction side of compressor from evaporator to allow for isolation and storage of full refrigerant charge in the chiller evaporator shell, **as directed**.
- 10. Evaporator:
  - a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from condenser.
  - b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
  - c. Designed to prevent liquid refrigerant carryover from entering compressor.
  - d. Provide evaporator with sight glass or other form of positive visual verification of liquid-refrigerant level.
  - e. Tubes:
    - 1) Individually replaceable from either end and without damage to tube sheets and other tubes.
    - 2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
    - 3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
    - 4) Nominal OD: Manufacturer's choice **OR** 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**.
    - 5) Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
    - 6) External Finish: Manufacturer's standard.
    - 7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
  - f. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
  - g. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.

- h. Water Box:
- 1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - 2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
  - 3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
  - 4) Hinged **OR** Davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** Davited, **as directed**, marine water-box covers.
  - 5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - 6) Thermistor or RTD temperature sensor factory installed in each nozzle.
  - 7) Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- i. Additional Corrosion Protection:
- 1) Electrolytic corrosion-inhibitor anode.
  - 2) Coat wetted surfaces with a corrosion-resistant finish.
11. Condenser:
- a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator.
  - b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
  - c. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
  - d. Provide condenser with sight glass or other form of positive visual verification of refrigerant charge and condition.
  - e. Tubes:
    - 1) Individually replaceable from either end and without damage to tube sheets and other tubes.
    - 2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
    - 3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
    - 4) Nominal OD: Manufacturer's choice **OR 3/4 inch (19 mm) OR 1 inch (25 mm)**, **as directed**.
    - 5) Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.
    - 6) External Finish: Manufacturer's standard.
    - 7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
  - f. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
  - g. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
  - h. Water Box:
    - 1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
    - 2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
    - 3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
    - 4) Hinged **OR** Davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** Davited, **as directed**, marine water-box covers.



- 5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
- 6) Thermistor or RTD temperature sensor factory installed in each nozzle.
- 7) Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- i. Additional Corrosion Protection:
  - 1) Electrolytic corrosion-inhibitor anode.
  - 2) Coat wetted surfaces with a corrosion-resistant finish.
12. Heat-Reclaim Condenser:
  - a. Description: Shell-and-tube design with water in tubes and refrigerant surrounding tubes within shell. Shell is separate from evaporator and condenser.
  - b. Shell Material: Carbon-steel rolled plates with continuously welded seams or seamless pipe.
  - c. Designed to prevent direct impingement of high-velocity hot gas from compressor discharge on tubes.
  - d. Tubes:
    - 1) Individually replaceable from either end and without damage to tube sheets and other tubes.
    - 2) Mechanically expanded into end sheets and physically attached to intermediate tube sheets.
    - 3) Material: Copper **OR** Copper-nickel alloy, **as directed**.
    - 4) Nominal OD: Manufacturer's choice **OR 3/4 inch (19 mm) OR 1 inch (25 mm)**, **as directed**.
    - 5) Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.
    - 6) External Finish: Manufacturer's standard.
    - 7) Internal Finish: Enhanced **OR** Smooth, **as directed**.
  - e. End Tube Sheets: Continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
  - f. Intermediate Tube Sheets: Installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
  - g. Water Box:
    - 1) Cast-iron or carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
    - 2) Standard **OR** Marine, **as directed**, type for water box with piping connections. Standard type for water box without piping connections.
    - 3) Provide water boxes and marine water-box covers, **as directed**, with lifting lugs or eyebolts.
    - 4) Hinged **OR** Davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** Davited, **as directed**, marine water-box covers.
    - 5) Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
    - 6) Thermistor or RTD temperature sensor factory installed in each nozzle.
    - 7) Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
  - h. Additional Corrosion Protection:
    - 1) Electrolytic corrosion-inhibitor anode.
    - 2) Coat wetted surfaces with a corrosion-resistant finish.
13. Electrical Power:
  - a. Factory installed and wired, and functionally tested at factory before shipment.



- b. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
  - 1) Provide branch power circuit to each motor, electric heater, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
  - 2) NEMA- and ICS 2-rated motor controller for auxiliary motors, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller for each variable-speed motor furnished.
  - 3) Control-circuit transformer with primary and secondary side fuses.
- c. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
- d. Factory-installed wiring outside of enclosures shall be in metal raceway except make connections to each motor and heater with not more than a 24-inch (610-mm) length of liquidtight conduit.
- e. Factory install and wire capacitor bank for the purpose of power factor correction to 0.95 at all operating conditions.
  - 1) If capacitors are mounted in a dedicated enclosure, use same NEMA enclosure type as motor controller. Provide enclosure with service entrance knockouts and bushings for conduit.
  - 2) Capacitors shall be non-PCB dielectric fluid, metallized electrode design, low loss with low-temperature rise. The kVAR ratings shall be indicated and shall not exceed the maximum limitations set by NFPA 70. Provide individual cells as required.
  - 3) Provide each cell with current-limiting replaceable fuses and carbon-film discharge resistors to reduce residual voltage to less than 50 V within 1 minute after de-energizing.
  - 4) Provide a ground terminal and a terminal block or individual connectors for phase connection.
- 14. Motor Controller:
  - a. Enclosure: Factory installed, unit mounted **OR** Factory furnished, field mounted, **as directed**, NEMA 250 **OR** NEMA ICS 6, **as directed**, Type 1 **OR** Type 4 **OR** Type 4X **OR** Type 12, **as directed**, with hinged full-front access door with lock and key or padlock and key, **as directed**.
  - b. Control Circuit: Obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected control devices.
  - c. Overload Relay: Shall be sized according to UL 1995 or shall be an integral component of chiller control microprocessor.
  - d. Across-the-Line Controller: NEMA ICS 2, Class A, full voltage, nonreversing; include isolation switch and current-limiting fuses.
  - e. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition.
  - f. Autotransformer Reduced-Voltage Controller: NEMA ICS 2, closed transition; include isolation switch and current-limiting fuses.
  - g. Solid-State, Reduced-Voltage Controller: NEMA ICS 2.
    - 1) Surge suppressor in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
    - 2) Visual indication of motor and control status, including the following conditions:
      - a) Controller on.
      - b) Overload trip.
      - c) Loss of phase.
      - d) Starter fault.
  - h. Accessories: Devices shall be factory installed in controller enclosure unless otherwise indicated.
    - 1) Externally Operated, Door-Interlocked, **as directed**, Disconnect: Fused disconnect switch **OR** Nonfused disconnect switch **OR** Circuit breaker, **as directed**. Minimum



withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.

- 2) Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- 3) Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- 4) Control Relays: Time-delay relays.
- 5) Elapsed-Time Meters: Numerical readout in hours on face of enclosure.
- 6) Number-of-Starts Counter: Numerical readout on face of enclosure.
- 7) Meters: Panel type, **2-1/2 inches (64 mm) OR 4-1/4 inches (108 mm), as directed**, with 90 **OR** 120 **OR** 270, **as directed**,-degree scale and 1 **OR** 2, **as directed**, percent accuracy. Where indicated, provide transfer device with an off position. Meters shall indicate the following:
  - a) Ammeter: Output current for each phase, with current sensors rated to suit application.
  - b) Voltmeter: Output voltage for each phase.
  - c) Frequency Meter: Output frequency.
  - d) Real-time clock with current time and date.
  - e) Total run time.

**OR**

Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

- a) Selectable, digital display of the following:
  - i. Phase Currents, Each Phase: Plus or minus 1 percent.
  - ii. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
  - iii. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
  - iv. Three-Phase Real Power: Plus or minus 2 percent.
  - v. Three-Phase Reactive Power: Plus or minus 2 percent.
  - vi. Power Factor: Plus or minus 2 percent.
  - vii. Frequency: Plus or minus 0.5 percent.
  - viii. Integrated Demand with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
  - ix. Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
- b) Mounting: Display and control unit flush or semirecessed in instrument compartment door.
- 8) Phase-Failure, Phase-Reversal, Undervoltage Relays: Solid-state sensing circuit with adjustable undervoltage setting and isolated output contacts for hardwired connection.
- 9) Power Protection: Chiller shall shut down within six cycles of power interruption.
15. Variable Frequency Controller:
  - a. Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
  - b. Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
  - c. Enclosure: Unit mounted, NEMA 250, Type 1, **as directed**, with hinged full-front access door with lock and key.
  - d. Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
  - e. Technology: Pulse width modulated (PWM) output suitable for constant or variable torque loads.

- f. Output Rating: Three phase; with voltage proportional to frequency throughout voltage range.
- g. Operating Requirements:
  - 1) Input AC Voltage Tolerance: 460-V ac, plus 10 percent or 506 V maximum, **as directed**.
  - 2) Input frequency tolerance of 60 Hz, plus or minus 2 Hz.
  - 3) Capable of driving full load, without derating, under the following conditions:
    - a) Ambient Temperature: 0 to 40 deg C.
    - b) Relative Humidity: Up to 90 **OR** 95, **as directed**, percent (noncondensing).
    - c) Altitude: **3300 feet (1005 m) OR 6600 feet (2010 m), as directed**.
  - 4) Minimum Efficiency: 96 percent at 60 Hz, full load.
  - 5) Minimum Displacement Primary-Side Power Factor: 98 percent.
  - 6) Overload Capability: 1.05 times the full-load current for 7 seconds.
  - 7) Starting Torque: As required by compressor-drive assembly.
  - 8) Speed Regulation: Plus or minus 1 percent.
  - 9) Isolated control interface to allow controller to follow control signal over a 10:1 speed range.
  - 10) To avoid equipment resonant vibrations, provide critical speed lockout circuitry to allow bands of operating frequency at which controller shall not operate continuously.
  - 11) Capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.
- h. Internal Adjustability Capabilities:
  - 1) Minimum Output Frequency: 6 Hz.
  - 2) Maximum Output Frequency: 60 Hz.
  - 3) Acceleration: 2 seconds to 60 seconds.
  - 4) Deceleration: Zero seconds to 60 seconds.
  - 5) Current Limit: 30 to a minimum of 100 percent of maximum rating.
- i. Self-Protection and Reliability Features: Subjecting the controller to any of the following conditions shall not result in component failure or the need for replacement:
  - 1) Overtemperature.
  - 2) Short circuit at controller output.
  - 3) Ground fault at controller output. Variable frequency controller shall be able to start a grounded motor.
  - 4) Open circuit at controller output.
  - 5) Input undervoltage.
  - 6) Input overvoltage.
  - 7) Loss of input-phase.
  - 8) Reverse phase.
  - 9) AC line switching transients.
  - 10) Instantaneous overload, line to line or line to ground.
  - 11) Sustained overload exceeding 100 percent of controller rated current.
  - 12) Starting a rotating motor.
- j. Motor Protection: Controller shall protect motor against overvoltage and undervoltage, phase loss, reverse phase, overcurrent, overtemperature, and ground fault.
- k. Automatic Reset and Restart: Capable of three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Controller shall be capable of automatic restart on phase-loss, and overvoltage and undervoltage trips.
- l. Visual Indication: On face of controller enclosure or chiller control enclosure; indicating the following conditions:
  - 1) Power on.
  - 2) Run.
  - 3) Overvoltage.
  - 4) Line fault.
  - 5) Overcurrent.

- 6) External fault.
  - 7) Motor speed (percent).
  - 8) Fault or alarm status (code).
  - 9) Motor output voltage.
  - 10) Input kilovolt amperes.
  - 11) Total power factor.
  - 12) Input kilowatts.
  - 13) Input kilowatt-hours.
  - 14) Three-phase input voltage.
  - 15) Three-phase output voltage.
  - 16) Three-phase input current.
  - 17) Three-phase output current.
  - 18) Output frequency (Hertz).
  - 19) Elapsed operating time (hours).
  - 20) Diagnostic and service parameters.
  - m. Operator Interface: At controller or chiller control panel; with start-stop and auto-manual selector with manual-speed-control potentiometer.
  - n. Harmonic Distortion Filter: Factory mounted and wired to limit total voltage and current distortion to 5 percent.
16. Controls:
- a. Standalone and microprocessor based with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
  - b. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, hinged or lockable; factory wired with a single-point, field-power connection and a separate control circuit.
  - c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
    - 1) Date and time.
    - 2) Operating or alarm status.
    - 3) Fault history with not less than last 10 faults displayed.
    - 4) Set points of controllable parameters.
    - 5) Trend data.
    - 6) Operating hours.
    - 7) Number of chiller starts.
    - 8) Outdoor-air temperature or space temperature if required for chilled-water reset.
    - 9) Temperature and pressure of operating set points.
    - 10) Entering- and leaving-fluid temperatures of evaporator and condenser.
    - 11) Difference in fluid temperatures of evaporator and condenser.
    - 12) Fluid flow of evaporator and condenser.
    - 13) Fluid pressure drop of evaporator and condenser.
    - 14) Refrigerant pressures in evaporator and condenser.
    - 15) Refrigerant saturation temperature in evaporator and condenser.
    - 16) Pump status.
    - 17) Antirecycling timer status.
    - 18) Percent of maximum motor amperage.
    - 19) Current-limit set point.
    - 20) Compressor bearing temperature.
    - 21) Motor bearing temperature.
    - 22) Motor winding temperature.
    - 23) Oil temperature.
    - 24) Oil discharge pressure.
    - 25) Phase current.
    - 26) Percent of motor rated load amperes.
    - 27) Phase voltage.

- 28) Demand power (kilowatts).
- 29) Energy use (kilowatt-hours).
- 30) Power factor.
- d. Control Functions:
  - 1) Manual or automatic startup and shutdown time schedule.
  - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Evaporator fluid temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
  - 3) Current limit and demand limit.
  - 4) Condenser-fluid temperature.
  - 5) External chiller emergency stop.
  - 6) Antirecycling timer.
  - 7) Variable evaporator flow.
  - 8) Thermal storage.
  - 9) Heat reclaim.
- e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
  - 1) Low evaporator pressure or temperature; high condenser pressure.
  - 2) Low evaporator fluid temperature.
  - 3) Low oil differential pressure.
  - 4) High or low oil pressure.
  - 5) High oil temperature.
  - 6) High compressor-discharge temperature.
  - 7) Loss of condenser-fluid flow.
  - 8) Loss of evaporator-fluid flow.
  - 9) Motor overcurrent.
  - 10) Motor overvoltage.
  - 11) Motor undervoltage.
  - 12) Motor phase reversal.
  - 13) Motor phase failure.
  - 14) Sensor- or detection-circuit fault.
  - 15) Processor communication loss.
  - 16) Motor controller fault.
  - 17) Extended compressor surge.
- f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
- g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
- h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
- i. Communication Port: RS-232 port or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.
- j. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
  - 1) Hardwired Points:
    - a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours) **OR** power factor, **as directed**.
    - b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
  - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.



17. Insulation:
- Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
  - Thickness: **3/4 inch (19 mm) OR 1-1/2 inches (38 mm), as directed.**
  - Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
  - Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
    - Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
    - Seal seams and joints to provide a vapor barrier.
    - After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
18. Finish:
- Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
    - Provide at least one coat of primer with a total dry film thickness of at least **2 mils (0.05 mm).**
    - Provide at least two coats of alkyd-modified, vinyl enamel **OR epoxy OR polyurethane, as directed,** finish with a total dry film thickness of at least **4 mils (0.10 mm).**
    - Paint surfaces that are to be insulated before applying the insulation.
    - Paint installed insulation to match adjacent uninsulated surfaces.
    - Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner, **as directed.**
  - Provide the Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.
19. Accessories:
- Flow Switches:
    - If required and not factory installed, chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed,** and verify field-mounting location before installation.
    - Paddle Flow Switches:
      - Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
      - Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
      - Pressure rating equal to pressure rating of heat exchanger.
      - Construct body and wetted parts of Type 316 stainless steel.
      - House switch in a NEMA 250, Type 4, **as directed,** enclosure constructed of die-cast aluminum.
      - Vane length to suit installation.
  - OR**
  - Pressure Differential Switches:
    - Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
    - Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
    - Set Point: Screw type, field adjustable.
    - Electrical Connections: Internally mounted screw-type terminal blocks.
    - Switch Enclosure: NEMA 250, Type 4, **as directed.**



- l) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
- b. Vibration Isolation:
  - c. Chiller manufacturer shall furnish vibration isolation for each chiller.
    - 1) Neoprene Pad:
      - a) Two layers of **0.375-inch- (10-mm-)** thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
      - b) Fabricate pads from 40- to 50-durometer neoprene.
      - c) Provide stainless-steel square bearing plate to load the pad uniformly between **20 and 40 psig (138 and 276 kPa)** with a **0.12- to 0.16-inch (3- to 4-mm)** deflection.
    - OR**
    - Spring Isolator:
      - d) Stable in operation and designed for not less than 30 percent reserve deflection beyond actual operating conditions. Isolators shall be designed such that the Kx/Ky ratio shall be 1.0 or more for stability.
      - e) Provide PVC or neoprene-coated springs and hot-dip, galvanized-steel components. Aluminum components shall be etched and painted. Nuts, bolts, and washers shall be zinc electroplated.
      - f) Isolators shall be adjustable and with an open spring, having one or more coil springs attached to a top compression plate and a baseplate. An elastomeric pad with a minimum thickness of **0.25 inch (6 mm)** shall be bonded to the baseplate.
      - g) Spring assembly shall be removable and shall fit within a welded steel enclosure consisting of a top plate and rigid lower housing, which serves as a blocking device during installation. Isolated restraining bolts shall not be engaged during normal operation and shall connect the top plate and lower housing to prevent the isolated equipment from rising when drained of fluid.
      - h) Isolators shall be selected for a nominal **1-inch (25-mm) OR 2-inch (50-mm), as directed**, deflection.
  - d. Sound Barrier:
    - 1) Furnish removable and reusable sound-barrier covers over the compressor housing, hermetic motor, compressor suction and discharge piping, and condenser shell.
    - 2) Provide for repeated installation and removal without use of tape or caulk.
    - 3) Inner and outer cover shall consist of a PTFE-impregnated fiberglass cloth enclosing heavy-density, needled fiberglass insulation material with a mass-loaded vinyl acoustic barrier.
    - 4) Covers shall be double sewn and lock stitched with edges folded and sewn so no raw cut edges are exposed.
    - 5) Form covers around control devices, gages, conduit, piping, and supports without degrading sound-barrier performance.
    - 6) Continuously lap all exposed seams at least **2 inches (50 mm)** for better sound containment.
    - 7) Permanently label each section of cover to indicate its location, description, size, and number sequence.
    - 8) Randomly place stainless-steel quilting pins to prevent covers from shifting and sagging.

**B. Packaged, Water-Cooled, Multiple-Compressor Chillers**

1. Description: Factory-assembled and -tested **OR** run-tested, **as directed**, chiller with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
  - a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.



2. Fabricate chiller mounting base with reinforcement strong enough to resist chiller movement during a seismic event when chiller is anchored to field support structure.
3. Compressors:
  - a. Description: Positive displacement, hermetically sealed.
  - b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
  - c. Rotors: Manufacturer's standard one- or two-rotor design.
4. Service: Easily accessible for inspection and service.
  - a. Compressor's internal components shall be accessible without having to remove compressor-drive assembly from chiller.
  - b. Provide lifting lugs or eyebolts attached to casing.
5. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.
  - a. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
  - b. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
  - c. Condenser-Fluid Unloading Requirements over Operating Range: Constant-design entering condenser-fluid temperature **OR** Drop-in entering condenser-fluid temperature of **2.5 deg F (1.4 deg C)** drop for each 10 percent in capacity reduction, **as directed**.
6. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
  - a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
  - b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
  - c. Factory-installed and pressure-tested piping with isolation valves and accessories.
  - d. Oil compatible with refrigerant and chiller components.
  - e. Positive visual indication of oil level.
7. Vibration Control:
  - a. Vibration Balance: Balance chiller compressor and drive assembly to provide a precision balance that is free of noticeable vibration over the entire operating range.
    - 1) Overspeed Test: 25 percent above design operating speed.
  - b. Isolation: Mount individual compressors on vibration isolators.
8. Sound Control: Sound-reduction package shall consist of removable acoustic enclosures around the compressors and drive assemblies that are designed to reduce sound levels without affecting performance.
9. Compressor Motors:
  - a. Hermetically sealed and cooled by refrigerant suction gas.
  - b. High-torque, induction type with inherent thermal-overload protection on each phase.
10. Refrigerant Circuits:
  - a. Refrigerant: Type as indicated on Drawings.  
**OR**  
Refrigerant Type: R-134a **OR** HFC, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
  - b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - c. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction, **as directed**, and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core, **as directed**, filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
  - d. Pressure Relief Device:
    - 1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - 2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.

- e. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line to the condenser and the refrigerant liquid-line leaving the condenser to allow for isolation and storage of full refrigerant charge in the chiller condenser shell.
- 11. Evaporator:
  - a. Description: Shell-and-tube design.
    - 1) Direct-expansion (DX) type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
    - 2) Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
  - b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  - c. Shell Material: Carbon steel.
  - d. Shell Heads: Removable carbon-steel heads with multipass baffles, and located at each end of the tube bundle.
  - e. Fluid Nozzles: Terminated with mechanical-coupling or flanged end connections for connection to field piping.
  - f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
- 12. Condenser:
  - a. Shell and tube, or without integral condenser, as indicated.  
**OR**  
Shell and Tube:
    - 1) Description: Shell-and-tube design with refrigerant flowing through shell, and fluid flowing through tubes within shell.
    - 2) Provides positive subcooling of liquid refrigerant.
    - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - 4) Shell Material: Carbon steel.
    - 5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
    - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
    - 7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.
  - b. Provide chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 23 Section "Air-cooled Refrigerant Condensers".
- 13. Electrical Power:
  - a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a multipoint **OR** single-point, **as directed**, field-power connection to chiller.
  - b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key, **as directed**.
  - c. Wiring shall be numbered and color-coded, **as directed**, to match wiring diagram.
  - d. Install factory wiring outside of an enclosure in a raceway.
  - e. Field-power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch **OR** NEMA AB 1, instantaneous-trip circuit breaker with lockable handle, **as directed**.
    - 1) Disconnect means shall be interlocked with door operation.
    - 2) Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
  - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
    - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.

- 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
- g. Provide each motor with overcurrent protection.
- h. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
- i. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.
- j. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- k. Control Relays: Auxiliary and adjustable time-delay relays.
- l. For chiller electrical power supply, indicate the following:
  - 1) Current and phase to phase for all three phases.
  - 2) Voltage, phase to phase, and phase to neutral for all three phases.
  - 3) Three-phase real power (kilowatts).
  - 4) Three-phase reactive power (kilovolt amperes reactive).
  - 5) Power factor.
  - 6) Running log of total power versus time (kilowatt-hours).
  - 7) Fault log, with time and date of each.
14. Compressor Motor Controllers:
  - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing, or solid state, **as directed**.
  - b. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed or open transition, or solid state, **as directed**.
15. Controls:
  - a. Standalone and microprocessor based.
  - b. Enclosure: Share enclosure with electrical-power devices or provide a separate enclosure of matching construction.
  - c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
    - 1) Date and time.
    - 2) Operating or alarm status.
    - 3) Fault history with not less than last 10 faults displayed.
    - 4) Set points of controllable parameters.
    - 5) Trend data.
    - 6) Operating hours.
    - 7) Number of chiller starts.
    - 8) Outdoor-air temperature or space temperature if required for chilled-water reset.
    - 9) Temperature and pressure of operating set points.
    - 10) Entering- and leaving-fluid temperatures of evaporator and condenser.
    - 11) Difference in fluid temperatures of evaporator and condenser.
    - 12) Refrigerant pressures in evaporator and condenser.
    - 13) Refrigerant saturation temperature in evaporator and condenser.
    - 14) No cooling load condition.
    - 15) Elapsed time meter (compressor run status).
    - 16) Pump status.
    - 17) Antirecycling timer status.
    - 18) Percent of maximum motor amperage.
    - 19) Current-limit set point.
    - 20) Number of compressor starts.
    - 21) Compressor refrigerant suction and discharge temperature.
    - 22) Oil temperature.
    - 23) Oil discharge pressure.
    - 24) Phase current.
    - 25) Percent of motor rated load amperes.
    - 26) Phase voltage.

- d. Control Functions:
    - 1) Manual or automatic startup and shutdown time schedule.
    - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
    - 3) Current limit and demand limit.
    - 4) Condenser-fluid temperature.
    - 5) External chiller emergency stop.
    - 6) Antirecycling timer.
    - 7) Automatic lead-lag switching.
    - 8) Variable evaporator flow.
    - 9) Thermal storage.
  - e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
    - 1) Low evaporator pressure, or high condenser pressure.
    - 2) Low chilled-water temperature.
    - 3) Refrigerant high pressure.
    - 4) High or low oil pressure.
    - 5) High oil temperature.
    - 6) Loss of chilled-water flow.
    - 7) Loss of condenser-fluid flow.
    - 8) Control device failure.
  - f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
  - g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
  - h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
  - i. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
    - 1) Hardwired Points:
      - a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours), **as directed**.
      - b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
    - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.
16. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
  - b. Thickness: **3/4 inch (19 mm)**.
  - c. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
  - d. Factory-applied insulation over cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets, evaporator water boxes including nozzles, refrigerant suction pipe from evaporator to compressor, cold surfaces of compressor, refrigerant-cooled motor, and auxiliary piping.
    - 1) Before insulating steel surfaces, prepare surfaces for paint, prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
    - 2) Seal seams and joints to provide a vapor barrier.



- 3) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
17. Finish:
  - a. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
    - 1) Provide at least one coat of primer.
    - 2) Provide finish coat of alkyd-modified, vinyl enamel, **as directed**.
    - 3) Paint surfaces that are to be insulated before applying the insulation.
    - 4) Paint installed insulation to match adjacent uninsulated surfaces.
18. Accessories:
  - a. Factory-furnished, chilled- and condenser-, **as directed**, water flow switches for field installation.
  - b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
  - c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.
- C. Packaged, Air-Cooled Chillers
  1. Description: Factory-assembled and run-tested chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
  2. Fabricate base, frame, and attachment to chiller components strong enough to resist chiller movement during a seismic event when chiller base is anchored to field support structure.
  3. Cabinet:
    - a. Base: Galvanized-steel base extending the perimeter of chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
    - b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported by base.
    - c. Casing: Galvanized steel.
    - d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500 **OR** 1000, **as directed**, -hour salt-spray test according to ASTM B 117.
    - e. Sound-reduction package designed to reduce sound level without affecting performance and consisting of the following:
      - 1) Acoustic enclosure around compressors.
      - 2) Reduced-speed fans with acoustic treatment.
    - f. Security Package: Provide removable grilles **OR** louvered panels, **as directed**, with fasteners for additional protection of compressors, evaporator, and condenser coils without inhibiting service access. Finish to match cabinet.
  4. Compressors:
    - a. Description: Positive displacement, hermetically sealed.
    - b. Casing: Cast iron, precision machined for minimum clearance about periphery of rotors.
    - c. Rotors: Manufacturer's standard one- or two-rotor design.
    - d. Each compressor provided with suction and, **as directed**, discharge shutoff valves, crankcase oil heater, and suction strainer.
  5. Service: Easily accessible for inspection and service.
  6. Capacity Control: On-off compressor cycling and modulating slide-valve assembly or port unloaders combined with hot-gas bypass, if necessary, to achieve performance indicated.
  7. Maintain stable operation throughout range of operation. Configure to achieve most energy-efficient operation possible.
    - a. Operating Range: From 100 to 20 **OR** 15 **OR** 10 **OR** 5 **OR** zero, **as directed**, percent of design capacity.
    - b. Condenser-Air Unloading Requirements over Operating Range: Constant-design entering condenser-air temperature **OR** Drop-in entering condenser-air temperature of 5 deg F (3 deg C) drop for each 10 percent in capacity reduction, **as directed**.

- c. For units equipped with a variable frequency controller, capacity control shall be both "valveless" and "stepless," requiring no slide valve or capacity-control valve(s) to operate at reduced capacity.
8. Oil Lubrication System: Consisting of pump if required, filtration, heater, cooler, factory-wired power connection, and controls.
  - a. Provide lubrication to bearings, gears, and other rotating surfaces at all operating, startup, shutdown, and standby conditions including power failure.
  - b. Thermostatically controlled oil heater properly sized to remove refrigerant from oil.
  - c. Factory-installed and pressure-tested piping with isolation valves and accessories.
  - d. Oil compatible with refrigerant and chiller components.
  - e. Positive visual indication of oil level.
9. Vibration Control:
  - a. Vibration Balance: Balance chiller compressors and drive assemblies to provide a precision balance that is free of noticeable vibration over the entire operating range.
    - 1) Overspeed Test: 25 percent above design operating speed.
  - b. Isolation: Mount individual compressors on vibration isolators.
10. Compressor Motors:
  - a. Hermetically sealed and cooled by refrigerant suction gas.
  - b. High-torque, induction type with inherent thermal-overload protection on each phase.
11. Compressor Motor Controllers:
  - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing, or solid state, **as directed**.
  - b. Star-Delta, Reduced-Voltage Controller: NEMA ICS 2, closed transition, or solid state, **as directed**.
  - c. Variable Frequency Controller:
    - 1) Motor controller shall be factory mounted and wired on the chiller to provide a single-point, field-power termination to the chiller and its auxiliaries.
    - 2) Description: NEMA ICS 2; listed and labeled as a complete unit and arranged to provide variable speed by adjusting output voltage and frequency.
    - 3) Enclosure: Unit mounted, NEMA 250, Type 3R, **as directed**, with hinged full-front access door with lock and key.
    - 4) Integral Disconnecting Means: Door-interlocked, **as directed**, NEMA AB 1, instantaneous-trip circuit breaker with lockable handle. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR 65,000 OR 100,000, as directed**, A.
    - 5) Technology: Pulse width modulated (PWM) output suitable for constant or variable torque loads.
    - 6) Motor current at start shall not exceed the rated load amperes, providing no electrical inrush.
12. Refrigerant Circuits:
  - a. Refrigerant: Type as indicated on Drawings.  
**OR**  
Refrigerant Type: R-134a **OR** R-407c **OR** HFC, **as directed**: Classified as Safety Group A1 according to ASHRAE 34.
  - b. Refrigerant Compatibility: Chiller parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - c. Refrigerant Circuit: Each shall include a thermal- or electronic-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction, **as directed**, and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core, **as directed**, filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
  - d. Pressure Relief Device:
    - 1) Comply with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
    - 2) ASME-rated, spring-loaded pressure relief valve; single- or multiple-reseating type.
13. Evaporator:



- a. Description: Shell-and-tube design.
    - 1) Direct-expansion (DX) type with fluid flowing through the shell, and refrigerant flowing through the tubes within the shell.
    - 2) Flooded type with fluid flowing through tubes and refrigerant flowing around tubes within the shell.
  - b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
  - c. Shell Material: Carbon steel.
  - d. Shell Heads: Removable carbon-steel heads located at each end of the tube bundle.
  - e. Fluid Nozzles: Terminated with mechanical-coupling **OR** flanged, **as directed**, end connections for connection to field piping.
  - f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
  - g. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to **minus 20 deg F (minus 29 deg C)**.
  - h. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.
14. Air-Cooled Condenser:
- a. Plate-fin coil with integral subcooling on each circuit, rated at **450 psig (3103 kPa)**.
    - 1) Construct coil casing of galvanized **OR** stainless, **as directed**, steel.
    - 2) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.
    - 3) Coat coils with a baked-epoxy, corrosion-resistant coating after fabrication.
    - 4) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
  - b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
  - c. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings. Equip each motor with overload protection integral to either the motor or chiller controls.
  - d. Fan Guards: Steel safety guards with corrosion-resistant coating.
15. Electrical Power:
- a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a multipoint **OR** single-point, **as directed**, field-power connection to chiller.
  - b. House in a unit-mounted, NEMA 250, Type 3R, **as directed**, enclosure with hinged access door with lock and key or padlock and key, **as directed**.
  - c. Wiring shall be numbered and color-coded, **as directed**, to match wiring diagram.
  - d. Install factory wiring outside of an enclosure in a raceway.
  - e. Field-power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch **OR** NEMA AB 1, instantaneous-trip circuit breaker with lockable handle, **as directed**.
    - 1) Disconnect means shall be interlocked with door operation.
    - 2) Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A.
  - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
    - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
  - g. Provide each motor with overcurrent protection.
  - h. Overload relay sized according to UL 1995 or an integral component of chiller control microprocessor.
  - i. Phase-Failure and Undervoltage Relays: Solid-state sensing with adjustable settings.



- j. Provide power factor correction capacitors to correct power factor to 0.90 **OR** 0.95, **as directed**, at full load.
  - k. Control Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
    - 1) Power unit-mounted controls where indicated.
    - 2) Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.
  - l. Control Relays: Auxiliary and adjustable time-delay relays.
  - m. For chiller electrical power supply, indicate the following:
    - 1) Current and phase to phase for all three phases.
    - 2) Voltage, phase to phase, and phase to neutral for all three phases.
    - 3) Three-phase real power (kilowatts).
    - 4) Three-phase reactive power (kilovolt amperes reactive).
    - 5) Power factor.
    - 6) Running log of total power versus time (kilowatt-hours).
    - 7) Fault log, with time and date of each.
16. Controls:
- a. Standalone and microprocessor based.
  - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure for remote mounting in the field, **as directed**.
  - c. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units, display the following information:
    - 1) Date and time.
    - 2) Operating or alarm status.
    - 3) Operating hours.
    - 4) Outdoor-air temperature if required for chilled-water reset.
    - 5) Temperature and pressure of operating set points.
    - 6) Entering and leaving temperatures of chilled water.
    - 7) Refrigerant pressures in evaporator and condenser.
    - 8) Saturation temperature in evaporator and condenser.
    - 9) No cooling load condition.
    - 10) Elapsed time meter (compressor run status).
    - 11) Pump status.
    - 12) Antirecycling timer status.
    - 13) Percent of maximum motor amperage.
    - 14) Current-limit set point.
    - 15) Number of compressor starts.
  - d. Control Functions:
    - 1) Manual or automatic startup and shutdown time schedule.
    - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limits. Chilled-water leaving temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
    - 3) Current limit and demand limit.
    - 4) External chiller emergency stop.
    - 5) Antirecycling timer.
    - 6) Automatic lead-lag switching.
    - 7) Variable evaporator flow.
    - 8) Thermal storage.
  - e. Manually Reset Safety Controls: The following conditions shall shut down chiller and require manual reset:
    - 1) Low evaporator pressure or high condenser pressure.
    - 2) Low chilled-water temperature.
    - 3) Refrigerant high pressure.
    - 4) High or low oil pressure.
    - 5) High oil temperature.
    - 6) Loss of chilled-water flow.

- 7) Control device failure.
  - f. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
  - g. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
  - h. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
  - i. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
    - 1) Hardwired Points:
      - a) Monitoring: On-off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt-hours), **as directed**.
      - b) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
    - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.
17. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
  - b. Thickness: **3/4 inch (19 mm) OR 1-1/2 inches (38 mm), as directed**.
  - c. Factory-applied insulation over cold surfaces of chiller components.
    - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
  - d. Apply protective coating to exposed surfaces of insulation to protect insulation from weather.
18. Accessories:
- a. Factory-furnished, chilled-water flow switches for field installation.
  - b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigerant circuit.
  - c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.
- D. Packaged Refrigerant Recovery Units
1. Packaged portable unit consisting of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest chiller furnished.
- E. Heat-Exchanger, Brush-Cleaning System
1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.
  2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
  3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
  4. Components:

- a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed **0.025 inch (0.6 mm)**.
  - b. Basket: Single-piece polypropylene basket with neck OD to press fit ID of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
  - c. Four-Way Valve:
    - 1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
    - 2) Configure valve with parallel flow connections to minimize field installation piping.
    - 3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
    - 4) Pipe connections shall be flanged.
    - 5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
    - 6) Hydrostatically test to 1.5 times the design working pressure.
    - 7) Design the valve to cause no more than **0.5-psig (3-kPa)** pressure drop at design flow conditions.
    - 8) Provide valve with valve-mounted indicating/warning light, which shall light before valve begins rotation.
    - 9) Valve Actuator: Mount electric actuator to operate valve.  
**OR**  
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
    - 10) Position Switches: Factory mount microswitches on valve to indicate the complete turn of valve in both normal and reverse flow.
  - d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
    - 1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
    - 2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
    - 3) Manual override of preset cleaning cycle.
    - 4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.
    - 5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
    - 6) Flow switch bypass.
    - 7) Unloading signal to chiller.
- F. Source Quality Control
1. Perform functional tests of chillers before shipping.
  2. Factory run test each air-cooled chiller with water flowing through evaporator.
  3. Factory performance test water-cooled chillers, before shipping, according to ARI 550/590.
    - a. Test the following conditions:
      - 1) Design conditions indicated.
      - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.  
**OR**  
Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in **5 deg F (3 deg C)** increments.  
**OR**  
At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
    - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.

- c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
4. Factory performance test air-cooled chillers, **as directed**, before shipping, according to ARI 550/590.
  - a. Test the following conditions:
    - 1) Design conditions indicated.
    - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser air at design conditions.

**OR**

At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
  - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
  - c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
5. Factory sound test water-cooled chillers, **as directed**, before shipping, according to ARI 575 **OR** air-cooled chillers, before shipping, according to ARI 370, **as directed**.
  - a. Test the following conditions:
    - 1) Design conditions indicated.
    - 2) Chiller operating at calculated worst-case sound condition.

**OR**

At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
  - b. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
  - c. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.
6. Factory test and inspect evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
7. For chillers located indoors, rate sound power level according to ARI 575.
8. For chillers located outdoors, rate sound power level according to ARI 370.

### 1.3 EXECUTION

#### A. Chiller Installation

1. Install chillers on support structure indicated.
2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1/2 inch (13 mm) OR 1 inch (25 mm) OR 2 inches (50 mm), as directed.**
  - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install chiller using elastomeric pads **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

- a. Minimum Deflection: **1/4 inch (6 mm) OR 1/2 inch (13 mm) OR 1 inch (25 mm) OR 2 inches (50 mm), as directed.**
  4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
    - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
    - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
    - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
  5. Maintain manufacturer's recommended clearances for service and maintenance.
  6. Charge chiller with refrigerant and fill with oil if not factory installed.
  7. Install separate devices furnished by manufacturer and not factory installed.
- B. Heat-Exchanger, Brush-Cleaning System Installation
  1. Install brush-cleaning system control panel adjacent to chiller control panel.
  2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
  3. Provide field electric power, as required, to each system control panel and electric actuated valve.
  4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
  5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
  6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.
- C. Connections
  1. Comply with requirements for piping specified in Division 23 Section(s) "Hydronic Piping" AND "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to chiller to allow service and maintenance.
  3. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
  4. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
  5. Heat-Reclaim Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
  6. Refrigerant Pressure Relief Device Connections: For chillers installed indoors, extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect vent to chiller pressure relief device with flexible connector and dirt leg with drain valve.
  7. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
  - a. Complete installation and startup checks according to manufacturer's written instructions.
  - b. Verify that refrigerant charge is sufficient and chiller has been leak tested.
  - c. Verify that pumps are installed and functional.
  - d. Verify that thermometers and gages are installed.
  - e. Operate chiller for run-in period.
  - f. Check bearing lubrication and oil levels.
  - g. For chillers installed indoors, verify that refrigerant pressure relief device is vented outdoors.
  - h. Verify proper motor rotation.
  - i. Verify static deflection of vibration isolators, including deflection during chiller startup and shutdown.
  - j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser **OR** condenser, and heat-reclaim condenser, **as directed**.
  - k. Verify and record performance of chiller protection devices.
  - l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
3. Prepare test and inspection startup reports.

END OF SECTION 23 61 16 00a



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Task	Specification	Specification Description
23 61 23 00	23 61 16 00a	Rotary-Screw Water Chillers

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## SECTION 23 62 13 00 - INDIRECT-FIRED ABSORPTION WATER CHILLERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for indirect-fired absorption water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Packaged, water-cooled, single-effect and double-effect absorption chillers.
  - b. Heat-exchanger, brush-cleaning system.

#### C. Definitions

1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. IPLV: Integrated part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 560 and referenced to ARI standard rating conditions.
4. NPLV: Nonstandard part-load value. A single-number part-load efficiency figure of merit calculated per the method defined by ARI 560 and intended for operating conditions other than the ARI standard rating conditions.

#### D. Performance Requirements

1. Seismic Performance: Indirect-fired absorption chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
  - a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of **60 deg F (16 deg C) OR 55 deg F (13 deg C) OR 40 deg F (4.4 deg C), as directed**, and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
  - b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of **65 deg F (18 deg C) OR 60 deg F (16 deg C) OR 55 deg F (13 deg C), as directed**.
  - c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 560, **as directed**:
  - a. Allowable Capacity Tolerance: Zero percent.
  - b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

#### E. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties and accessories.
2. LEED Submittals:
  - a. Product Data for LEED-NC Prerequisite EA 2: Documentation indicating that units comply with ASHRAE 90.1.



- b. Product Data for LEED-NC Prerequisite EA 3: Documentation indicating that refrigerants comply.
- c. Product Data for LEED-NC Credit EA 4: Documentation indicating that equipment and refrigerants comply.
- 3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
- 4. Certificates: For certification required in "Quality Assurance" Article.
- 5. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 6. Startup service reports.
- 7. Operation and maintenance data.
- 8. Warranty: Sample of special warranty.

F. Quality Assurance

- 1. ARI Rating: Rate chiller performance according to requirements in ARI 560.
- 2. ASHRAE Compliance:
  - a. ASHRAE 15 for safety code for mechanical refrigeration.
  - b. ASHRAE/IESNA 90.1.
- 3. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.
- 4. Comply with NFPA 70.
- 5. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.

G. Delivery, Storage, And Handling

- 1. Ship chillers factory charged with nitrogen.
- 2. Ship absorbent and refrigerant in chillers or in containers separate from chillers.  
**OR**  
Ship absorbent and refrigerant, **as directed**, in containers separate from chillers.
- 3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.

H. Warranty

- 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
  - a. Extended warranties include, but are not limited to, the following:
    - 1) Complete chiller.  
**OR**  
Pumps and motors **OR** Purge unit, **as directed**.  
**OR**  
Absorbent **OR** Absorbent and refrigerant, **as directed**, only.
    - 2) Parts only **OR** Parts and labor, **as directed**.
    - 3) Loss of absorbent and refrigerant for any reason.
- 2. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Final Completion.

## 1.2 PRODUCTS

A. Manufactured Unit

1. Description: Factory-assembled and -tested, hermetic-design chiller complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.
    - a. Disassemble chiller into major assemblies as required by the installation after factory testing and before packaging for shipment.
  2. Absorbent and Refrigerant:
    - a. Absorbent: Lithium bromide solution with corrosion inhibitor.
    - b. Refrigerant: Deionized or distilled, **as directed**, water.
    - c. Performance Enhancer: Heat and mass transfer enhancer to improve performance.
  3. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- B. Pumps
1. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating tapered carbon bearings.
  2. Pump motor assembly shall be designed to operate for not less than 25,000 **OR** 50,000, **as directed**, hours between inspections.
  3. Pump motors cooled, and bearings lubricated, either by fluid being pumped or by a filtered supply of liquid refrigerant.
  4. Pump suction and discharge equipped with isolation valves.
  5. Separate and dedicated pumps for absorbent solution and refrigerant.
    - a. Absorbent solution and refrigerant flow-control method shall be manufacturer's choice to comply with operating requirements indicated.
  6. Purge System: Unit mounted and factory wired, equipped with controls and a pump to automatically remove noncondensable vapors.
    - a. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Enclosure: Open dripproof **OR** Totally enclosed, **as directed**.
- C. Heat-Exchanger Shells
1. Configuration for Single-Effect Chillers: Two shells; one shell consists of the absorber/evaporator and the other shell consists of the condenser/generator.
  2. Configuration for Double-Effect Chillers: Two shells; one shell consists of the absorber/evaporator, low-stage generator/condenser and the other shell consists of the high-stage generator.
  3. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.
  4. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.
  5. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes with positive seal between fluid in tubes and refrigerant in shell.
  6. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid contact of tubes resulting in abrasion and wear.
  7. Generator/Condenser Shell Pressure Relief Device: Manufacturers standard rupture disk complying with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. Absorber
1. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes. Constructed of brass, stainless steel, or another material that will not corrode.
  2. Tubes:

- a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
  - b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
  - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
  - d. External Finish: Manufacturer's standard.
  - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
3. Water Boxes:
- a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard **OR** Marine, **as directed**, type for water box with piping connections.
    - 1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
    - 2) Hinged **OR** davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** davited, **as directed**, marine water-box covers.
  - OR**  
Standard type for water box without piping connections.
    - 1) Water boxes shall have lifting lugs or eyebolts.
    - 2) Hinged **OR** davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** davited, **as directed**, marine water-box covers.
  - c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - d. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - e. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm) **OR** 3/4- or 1-inch (19- or 25-mm), **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
4. Additional Corrosion Protection:
- a. Electrolytic corrosion-inhibitor anode.
  - b. Coat wetted surfaces with a corrosion-resistant finish.  
**OR**  
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
5. Absorber/Condenser Crossover Piping: Factory furnished **OR** installed, **as directed**, piping connecting fluid connection of absorber discharge to condenser inlet.

#### E. Evaporator

- 1. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes. Constructed of brass, stainless steel, or another material that will not corrode.
- 2. Refrigerant Holding Pan: Steel **OR** Stainless steel, **as directed**.
- 3. Tubes:
  - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
  - b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
  - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.025 inch (0.6 mm) **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), **as directed**.
  - d. External Finish: Manufacturer's standard.
  - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
- 4. Water Boxes:
  - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard **OR** Marine, **as directed**, type for water box with piping connections.

- 1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
  - 2) Hinged **OR** davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** davited, **as directed**, marine water-box covers.
  - OR**  
Standard type for water box without piping connections.
    - 1) Water boxes shall have lifting lugs or eyebolts.
    - 2) Hinged **OR** davited, **as directed**, water boxes.
  - OR**  
Hinged **OR** davited, **as directed**, marine water-box covers.
  - c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - d. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - e. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm) OR 3/4- or 1-inch (19- or 25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- F. Condenser
1. Refrigerant Holding Pan: Steel **OR** Stainless steel, **as directed**.
  2. Tubes:
    - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
    - b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
    - c. Minimum Wall Thickness: Manufacturer's choice **OR** **0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.
    - d. External Finish: Manufacturer's standard.
    - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
  3. Water Boxes:
    - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
    - b. Standard **OR** Marine, **as directed**, type for water box with piping connections.
      - 1) Water boxes and marine water-box covers, **as directed**, shall have lifting lugs or eyebolts.
      - 2) Hinged **OR** davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** davited, **as directed**, marine water-box covers.
    - OR**  
Standard type for water box without piping connections.
      - 1) Water boxes shall have lifting lugs or eyebolts.
      - 2) Hinged **OR** davited, **as directed**, water boxes.
    - OR**  
Hinged **OR** davited, **as directed**, marine water-box covers.
  - c. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - d. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - e. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
  4. Additional Corrosion Protection:
    - a. Electrolytic corrosion-inhibitor anode.
    - b. Coat wetted surfaces with a corrosion-resistant finish.  
**OR**  
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

**G. Generator For Single-Effect Chillers**

1. Tubes:
  - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
  - b. Material: 90/10 copper-nickel alloy **OR** Stainless steel **OR** Titanium, as directed.
  - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.035 inch (0.9 mm), as directed.
  - d. External Finish: Manufacturer's standard.
  - e. Internal Finish: Smooth **OR** Enhanced, as directed
2. Water Boxes:
  - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard type water box.
  - c. Water boxes shall have lifting lugs or eyebolts.
  - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, as directed.
  - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), as directed, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
  - a. Electrolytic corrosion-inhibitor anode.
  - b. Coat wetted surfaces with a corrosion-resistant finish.  
**OR**  
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

**H. First-Stage Generator For Double-Effect Chillers**

1. Tubes:
  - a. Replaceable, straight, or U tubes expanded into tube sheets.
  - b. Material: Manufacturer's standard **OR** 70/30 copper-nickel alloy **OR** Type 409 stainless steel **OR** Titanium, as directed.
  - c. Minimum Wall Thickness: Manufacturer's choice **OR** 0.028 inch (0.7 mm) **OR** 0.035 inch (0.9 mm), as directed.
  - d. External Finish: Manufacturer's standard.
  - e. Internal Finish: Smooth **OR** Enhanced, as directed.
2. Water Boxes:
  - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard type water box.
  - c. Water boxes shall have lifting lugs or eyebolts.
  - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, as directed.
  - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - f. Fit each water box with 3/4-inch (19-mm) **OR** 1-inch (25-mm), as directed, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
  - a. Electrolytic corrosion-inhibitor anode.
  - b. Coat wetted surfaces with a corrosion-resistant finish.  
**OR**  
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

**I. Second-Stage Generator For Double-Effect Chillers**

1. Tubes:



- a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end and without damage to tube sheets and other tubes.
- b. Material: Copper **OR** Copper-nickel alloy **OR** Stainless steel **OR** Titanium, **as directed**.
- c. Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm), as directed**.
- d. External Finish: Manufacturer's standard.
- e. Internal Finish: Smooth **OR** Enhanced, **as directed**.
2. Water Boxes:
  - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard type water box.
  - c. Water boxes shall have lifting lugs or eyebolts.
  - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - f. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm), as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
3. Additional Corrosion Protection:
  - a. Electrolytic corrosion-inhibitor anode.
  - b. Coat wetted surfaces with a corrosion-resistant finish.  
**OR**  
Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
- J. Solution Heat Exchanger
  1. Description: Shell-and-tube or brazed-plate heat exchanger; integral part of chiller to increase cycle efficiency by preheating the weak solution on its way to the generator while precooling the strong solution returning from the generator.
- K. Steam Condensate Drain Cooler
  1. Description: Shell-and-tube heat exchanger constructed of carbon-steel shell and copper-nickel-alloy or stainless-steel tubes.
- L. Factory-Applied Insulation
  1. Factory-Applied Insulation on Cold Surfaces:
    - a. Closed-cell, flexible elastomeric thermal insulation complying with ASTM C 534, Type I for tube and Type II for sheet materials.
      - 1) Thickness: **3/4 inch (19 mm) OR 1-1/2 inches (38 mm), as directed**.
    - b. Adhesive: As recommended by insulation manufacturer.
    - c. Factory apply insulation over all cold surfaces of chiller capable of forming condensation. Components shall include, but not be limited to, evaporator shell and end tube sheets; evaporator water boxes including nozzles; refrigerant pump; cold surfaces of motor; and cold piping.
      - 1) Apply adhesive to 100 percent of insulation contact surface.
      - 2) Before insulating steel surfaces, prepare surfaces for paint, and prime and paint as indicated for other painted components. Do not insulate unpainted steel surfaces.
      - 3) Seal seams and joints to provide a vapor barrier.
      - 4) After adhesive has fully cured, paint exposed surfaces of insulation to match other painted parts.
  2. Factory-Applied Insulation on Hot Surfaces:
    - a. Mineral-fiber board, pipe or tank insulation complying with one of following:
      - 1) ASTM C 547, Type I or Type II, Grade A.
      - 2) ASTM C 612, Type IB.
      - 3) ASTM C 1393, Type II or Type IIIA, Category 2.
      - 4) Thickness: **1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**.



- b. Adhesive: As recommended by insulation manufacturer.
- c. Factory apply materials over all hot surfaces to provide smooth, straight, and even surfaces; free of voids.
  - 1) Apply adhesive to insulation contact surface as recommended by insulation manufacturer.
  - 2) Install insulation anchor pins and washers if required by insulation manufacturer to secure insulation to surfaces to be insulated.
  - 3) Completely encapsulate insulation with metal jacket, leaving no exposed insulation. Provide removable jacket on components requiring access for service and inspection.
  - 4) Paint exposed surfaces of metal jacket to match other painted parts unless jacket material is aluminum or stainless steel.

#### M. Electrical

- 1. Factory installed and wired, and functionally tested at factory before shipment.
- 2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
  - a. Branch power circuit to each motor, dedicated electrical load, and controls with disconnect switch or circuit breaker, **as directed**.
    - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
  - b. NEMA ICS 2, Class A, full-voltage, nonreversing motor controller, hand-off-auto switch, and overcurrent protection for each motor.
  - c. Control-circuit transformer with primary and secondary side fuses.
- 3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
- 4. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight **OR** flexible metallic, **as directed**, conduit.

#### N. Controls

- 1. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
- 2. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x, **as directed**, hinged or lockable.
- 3. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. In either imperial or metric units selectable through the interface, display the following information:
  - a. Date and time.
  - b. Operating or alarm status.
  - c. Operating hours.
  - d. Outdoor-air temperature if required for chilled-water reset.
  - e. Temperature and pressure of operating set points.
  - f. Entering and leaving temperatures of chilled and condenser water.
  - g. Refrigerant temperature.
  - h. Solution concentration and temperature.
  - i. Indication of solution and purge-pump operation.
  - j. Generator shell pressure.
  - k. Number of starts.
  - l. Number of purge cycles.
  - m. Hot-water valve actuator potentiometer position (percentage).
  - n. Entering and leaving hot-water temperatures.

- o. Steam demand limit.
  - p. Inlet steam pressure and temperature.
  - q. Steam valve actuator potentiometer position (percentage).
  - r. First-stage generator pressure and temperature.
- 4. Control Functions:
  - a. Manual or automatic startup and shutdown time schedule.
  - b. Automatic cycle to prevent crystallization.
  - c. Entering and leaving chilled-water temperatures and control set points. Chilled-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
  - d. Condenser-fluid temperature.
  - e. Cooling provided and heating energy used within programmable time periods, minimum monthly.
- 5. Capacity Control: Automatically controls input flow rate of heat source to maintain chilled-water temperature set point for cooling loads ranging from 10 to 100 percent.
- 6. Control Valve Package: Factory-furnished, for field installation, **OR** Factory-installed, **as directed**, control valve package suitable for energy source indicated.
  - a. Body: Cast-iron, carbon-steel, or stainless-steel body with flanged connections.
  - b. Type: Manufacturer's choice **OR** V-notch ball **OR** Butterfly **OR** Globe style with cage-guide plug, **as directed**, constructed of stainless steel.
  - c. Rating: Pressure and temperature rating to match heat exchanger.
  - d. Shutoff: Capable of bubble-tight shutoff against maximum system pressure.
  - e. Size: Determined by chiller manufacturer.
  - f. Modulation: Two-way **OR** Three-way, **as directed**.
  - g. Turndown: As required to achieve stable control through the indicated operating range.
  - h. Actuator: Electric powered from chiller control panel and installed on valve.
- 7. Safety Shutdowns:
  - a. Crystallization.
  - b. Low refrigerant temperature.
  - c. Loss of chilled- or condenser-water flow.
  - d. Low leaving chilled-water temperature, **2 deg F (1 deg C)** below set point, **as directed**.
  - e. First-stage generator low-solution level.
  - f. First-stage generator high temperature or pressure.
  - g. Power failure.
  - h. Solution pump overloads.
  - i. External auxiliary safety shutdown.
  - j. High solution concentration.
  - k. Incomplete dilution cycle.
  - l. High entering-water temperature.
  - m. High inlet steam pressure and temperature.
- 8. Warning Conditions: Control panel shall close warning contacts and generate a message when one of the following operating conditions is detected:
  - a. Low refrigerant temperature.
  - b. High generator temperature or pressure.
  - c. High entering generator-water temperature (single-stage generator only).
  - d. High or low entering condenser-water temperature.
  - e. Solution temperature sensor failure.
  - f. Low chilled-water flow.
- 9. Trending: Capability to trend analog data of up to five parameters simultaneously over an adjustable period and frequency of polling.
- 10. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
- 11. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.



12. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer, **as directed**.
13. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
  - a. Hardwired Points:
    - 1) Monitoring: On-off status, common trouble alarm.
    - 2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** generator heat source capacity limiting, **as directed**.
  - b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.

O. Finish

1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
  - a. Provide at least one coat of primer with a total dry film thickness of at least **2 mils (0.05 mm)**.
  - b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least **4 mils (0.10 mm)**.
  - c. Paint surfaces that are to be insulated before applying the insulation.
  - d. Paint installed insulation to match adjacent uninsulated surfaces.
  - e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner.
2. Provide the Owner with quart container of paint used in application of topcoat to use in touchup applications after Project Closeout.

P. Accessories

1. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.
2. Flow Switches:
  - a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and verify field-mounting location before installation.
  - b. Paddle Flow Switches:
    - 1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
    - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
    - 3) Pressure rating equal to pressure rating of heat exchanger.
    - 4) Construct body and wetted parts of Type 316 stainless steel.
    - 5) House switch in a NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
    - 6) Vane length to suit installation.
  - OR**
  - Pressure Differential Switches:
    - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
    - 2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set-point shift due to variation in working pressure.
    - 3) Set Point: Screw type, field adjustable.
    - 4) Electrical Connections: Internally mounted screw-type terminal blocks.
    - 5) Switch Enclosure: NEMA 250, Type 4.
    - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
3. Vibration Isolation:
  - a. Chiller manufacturer shall furnish neoprene-pad vibration isolation for each chiller.

- 1) Two layers of 0.375-inch- (10-mm-) thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
  - 2) Fabricate pads from 40- to 50-durometer neoprene.
  - 3) Provide stainless-steel square bearing plate to load the pad uniformly between 20 and 40 psig (138 and 276 kPa) with a 0.12- to 0.16-inch (3- to 4-mm) deflection.
4. Lithium Bromide Filter, **as directed**:
- a. Factory install a filter, isolation valves, and associated piping.
  - b. Filter shall consist of a stainless-steel body, with removable and cleanable 150-micron, stainless-steel element.
  - c. Isolation valves shall provide isolation for filter servicing without disturbing operation of chiller.
- Q. Heat-Exchanger, Brush-Cleaning System
1. Furnish for field installation a brush-cleaning system on each chiller condenser, **as directed**, for tube cleaning and improved heat transfer.
  2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
  3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
  4. Components:
    - a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed 0.025 inch (0.6 mm).
    - b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
    - c. Four-Way Valve:
      - 1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
      - 2) Configure valve with parallel flow connections to minimize field installation piping.
      - 3) Construct to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, at a system working pressure equal to condenser.
      - 4) Pipe connections shall be flanged.
      - 5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
      - 6) Hydrostatically test to 1.5 times the design working pressure.
      - 7) Design the valve to cause no more than 0.5-psig (3-kPa) pressure drop at design flow conditions.
      - 8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
      - 9) Valve Actuator: Mount electric actuator to operate valve.  
**OR**  
Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.
      - 10) Position Switches: Factory mount microswitches on the valve to indicate the complete turn of valve in both normal and reverse flow.
    - d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
      - 1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
      - 2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
      - 3) Manual override of preset cleaning cycle.
      - 4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow turn or incomplete valve turn.



- 5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
- 6) Flow-switch bypass.
- 7) Unloading signal to chiller.

R. Source Quality Control

1. Perform functional tests **OR** run tests, **as directed**, of chillers before shipping.
2. Factory test and inspect absorber, generator, evaporator and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Vacuum and pressure test shells for leaks.
3. Rate sound power level according to ARI 575.
4. Factory performance test chillers, before shipping, according to ARI 560, **as directed**.
  - a. Test the following conditions:
    - 1) Design conditions indicated.
    - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.  
**OR**  
Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.  
**OR**  
At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
5. Factory sound test chillers, before shipping, according to ARI 575, **as directed**.
  - a. Test the following conditions:
    - 1) Design conditions indicated.
    - 2) Chiller operating at calculated worst-case sound condition.
    - 3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
6. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
7. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

### 1.3 EXECUTION

A. Chiller Installation

1. Install chillers on support structure indicated.
2. Equipment Mounting: Install chiller on concrete bases using elastomeric pads. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1/2 inch (13 mm), **as directed**.
  - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
  - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install chiller using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

- a. Minimum Deflection: **1/4 inch (6 mm) OR 1/2 inch (13 mm), as directed.**
  4. Equipment Mounting: Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
    - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
    - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
    - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
  5. Install chillers with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  6. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  7. Maintain manufacturer's recommended clearances for service and maintenance.
  8. Charge chiller with absorbent and refrigerant if not factory charged.
  9. Install separate devices furnished by manufacturer and not factory installed.
  10. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated, and are not factory insulated. Comply with requirements in Division 23 Section "Hvac Insulation".
- B. Heat-Exchanger, Brush-Cleaning System Installation
1. Install brush-cleaning system control panel adjacent to chiller control panel.
  2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
  3. Provide field electric power, as required, to each system control panel and electric actuated valve.
  4. Provide pneumatic piping with pressure regulator and isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
  5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
  6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.
- C. Connections
1. Comply with requirements in Division 23 Section "Hydronic Piping" for hydronic piping. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Comply with requirements in Division 23 Section "Steam And Condensate Heating Piping" for steam and condensate piping. Drawings indicate general arrangement of piping, fittings, and specialties.
  3. Install piping adjacent to chiller to allow service and maintenance.
  4. Generator Steam Piping Connections:
    - a. Connect steam piping with trapped drip leg, gate valve, strainer, control valve, and pressure gage. Install pressure reducing valve and safety relief valve upstream from steam-control valve to protect control valve from excessive steam pressure. Make connections to chiller with a flange **OR** union, **as directed.**
    - b. Connect steam condensate piping with vacuum breaker, trapped drip leg, gate valve, strainer, float and thermostatic trap(s), condensate cooler, **as directed**, condensate receiver, **as directed**, condensate receiver and pump, **as directed**, and check valve. Make connections to chiller with a flange **OR** union, **as directed.**
  5. Generator Hot-Water Connections: Connect to generator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, control valve, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to generator outlet with shutoff valve, check valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with



shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.

6. Evaporator-Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
7. Absorber/Condenser-Fluid Connections: Connect to inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to chiller with a flange **OR** mechanical coupling, **as directed**.
  - a. If not factory furnished or installed, provide pipe connecting fluid connection of absorber discharge and condenser inlet.
8. Refrigerant Pressure Relief Device Connections: Extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
9. Extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15.
10. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
  - a. Complete installation and startup checks according to manufacturer's written instructions.
  - b. Operate chiller for run-in period.
  - c. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
  - d. Verify that pumps are installed and functional.
  - e. Verify that thermometers and gages are installed.
  - f. Operate chiller for run-in period.
  - g. Verify that refrigerant pressure relief device is vented outside.
  - h. Verify proper motor rotation.
  - i. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
  - j. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
  - k. Verify and record performance of chiller protection devices.
  - l. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
3. Prepare test and inspection startup reports.

E. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain chillers.

END OF SECTION 23 62 13 00



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Task	Specification	Specification Description
23 62 23 00	23 01 60 71	Condensing Units

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## SECTION 23 63 13 00 - AIR-COOLED CONDENSERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for air-cooled condensers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged, air-cooled condensers for outdoor and indoor installation.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Signed and sealed by a qualified professional engineer.
  - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.
  - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails and equipment mounting frames.
  - c. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that air-cooled condensers, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Include the following:
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. LEED Submittal:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Fabricate and label refrigeration system according to ASHRAE 15, "Safety Code for Mechanical Refrigeration."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

### 1.2 PRODUCTS

#### A. Manufactured Units

1. Description: Factory assembled and tested; consisting of casing, condenser coils, condenser fans and motors, and unit controls.
2. Condenser Coil: Seamless copper-tube, finned coil; factory tested at 425 psig (2930 kPa).
  - a. Coil Fin: Aluminum **OR** Copper, **as directed**.
  - b. Coil Coating: **As directed**.
  - c. Circuit: To match compressors with liquid subcooling coil, **as directed**.
  - d. Refrigerant Accessories, **as directed**: Provide receiver, pressure control, and solenoid valve for each circuit.



3. Condenser Fans and Drives: Propeller fans with aluminum or galvanized-steel **OR** galvanized-steel **OR** stainless-steel, **as directed**, fan blades, for vertical **OR** horizontal, **as directed**, air discharge; directly driven with permanently lubricated ballbearing motors with integral current- and thermal-overload protection.

**OR**

Condenser Fans and Drives: Forward-curved centrifugal fans for vertical **OR** horizontal, **as directed**, air discharge.

- a. Fan on steel shaft with self-aligning ball bearings.
- b. V-belt drive with minimum of two belts; variable pitch drive pulley.
- c. Motor mounted on adjustable slide base.
4. Operating and Safety Controls: Include condenser fan motor thermal and overload cutouts; 115-V control transformer, if required; magnetic contactors for condenser fan motors and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
5. Unit Casings: Galvanized or zinc-coated steel treated and finished with manufacturer's standard paint coating **OR** Stainless steel, **as directed**, designed for outdoor installation with weather protection for components and controls **OR** indoor installation, **as directed**, and with the following:
  - a. Removable panels for access to controls, condenser fans, motors, and drives.
  - b. Plated-steel **OR** Stainless-steel, **as directed**, fan guards.
  - c. Lifting eyes.
  - d. Removable legs.
  - e. **1-inch- (25-mm-)** thick inlet filter.

#### B. Motors

1. General requirements for motors are specified in Division 14 Section "Facility Chutes".
  - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.

#### C. Source Quality Control

1. Verification of Performance: Rate air-cooled condensers according to ARI 460.
2. Testing Requirements: Factory test sound-power-level ratings according to ARI 270.

### 1.3 EXECUTION

#### A. Installation

1. Install units level and plumb, firmly anchored in locations indicated; maintain manufacturer's recommended clearances.
2. Install air-cooled condensers on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac" and concrete materials and installation requirements are specified in Division 31.
3. Concrete Bases:
  - a. Install dowel rods to connect concrete base to concrete slab. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around full perimeter of the base.
  - b. For equipment supported on structural slab, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - e. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
4. Install roof-mounting units on equipment supports specified in Division 07.

5. Vibration Isolation: Mount air-cooled condensers on rubber pads with a minimum deflection of **1/4 inch (6.35 mm)**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".  
**OR**  
Vibration Isolation: Mount air-cooled condensers on restrained spring isolators with a minimum deflection of **<Insert measurement>**. Vibration isolation devices and installation requirements are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  6. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of **1 inch (25 mm)**. Vibration- and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
    - a. Secure vibration and seismic controls, and suspended units to structure.**OR**  
Support suspended units from structure using threaded steel rods.
  7. Maintain manufacturer's recommended clearances for service and maintenance.
  8. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.
- B. Connections
1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to machine to allow service and maintenance.
  3. Refrigerant Piping: Connect piping to unit with pressure relief, service valve, filter-dryer, and moisture indicator on each refrigerant-circuit liquid line. Refrigerant piping and specialties are specified in Division 23 Section "Refrigerant Piping".
- C. Field Quality Control
1. Perform the following field tests and inspections and prepare test reports:
    - a. Perform electrical test and visual and mechanical inspection.
    - b. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
    - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Complete manufacturer's starting checklist.
    - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - e. Verify proper airflow over coils.
  2. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
  3. Remove and replace malfunctioning air-cooled condensers and retest as specified above.
- D. Startup Service
1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
    - a. Inspect for physical damage to unit casing.
    - b. Verify that access doors move freely and are weathertight.
    - c. Clean units and inspect for construction debris.
    - d. Verify that all bolts and screws are tight.
    - e. Adjust vibration isolation and flexible connections.
    - f. Verify that controls are connected and operational.
  2. Lubricate bearings on fans.
  3. Verify that fan wheel is rotating in the correct direction and is not vibrating or binding.
  4. Start unit according to manufacturer's written instructions and complete manufacturer's startup checklist.
  5. Measure and record airflow over coils.
  6. Verify proper operation of capacity control device.



7. Verify that vibration isolation and flexible connections properly dampen vibration transmission to structure.
  8. After startup and performance test, lubricate bearings.
- E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain air-cooled condensers.

END OF SECTION 23 63 13 00

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## SECTION 23 63 13 00a - SPLIT-SYSTEM AIR-CONDITIONING UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for split-system air-conditioning units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes split-system air-conditioning and heat pump units consisting of separate evaporator-fan and compressor-condenser components. Units are designed for exposed or concealed mounting, and may be connected to ducts.

#### C. Submittals

1. Product Data: For each unit indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
2. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Diagram power, signal, and control wiring.
4. Field quality-control test reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split-system air-conditioning units that fail in materials or workmanship within five years from date of Final Completion.

### 1.2 PRODUCTS

#### A. Concealed Evaporator-Fan Components

1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
  - a. Insulation: Faced, glass-fiber duct liner.
  - b. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1, **as directed**.
  - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
  3. Water **OR** Steam, **as directed**, Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; leak tested to **300 psig (2070 kPa)** underwater; and having a two-position control valve.  
**OR**  
Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
  4. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
  5. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
  6. Disposable Filters: **1 inch (25 mm)** thick, in fiberboard frames with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
  7. Wiring Terminations: Connect motor to chassis wiring with plug connection.
- B. Floor-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner.
    - a. Discharge Grille: Steel with surface-mounted frame **OR** Welded steel bars forming a linear grille and welded into supporting panel, **as directed**.
    - b. Insulation: Faced, glass-fiber, duct liner.
    - c. Drain Pans: Galvanized steel, with connection for drain; insulated and complying with ASHRAE 62.1, **as directed**.
    - d. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
  3. Water **OR** Steam, **as directed**, Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; leak tested to **300 psig (2070 kPa)** underwater; and having a 2-position control valve.  
**OR**  
Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
  4. Fan: Direct drive, centrifugal, with power-induced outside air, **as directed**.
  5. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
  6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
- C. Wall-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner, and discharge drain pans with drain connection.
    - a. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
    - b. Drain Pan and Drain Connection: Comply with ASHRAE 62.1.
  2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.

3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
  4. Fan: Direct drive, centrifugal fan.
  5. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
  6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
- D. Ceiling-Mounting, Evaporator-Fan Components
1. Cabinet: Enameled steel with removable panels on front and ends in color selected by the Owner, and discharge drain pans with drain connection.
    - a. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
    - b. Drain Pan and Drain Connection: Comply with ASHRAE 62.1.
  2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with thermal-expansion valve.
  3. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow proving device; and one-time fuses in terminal box for overcurrent protection.
  4. Fan: Direct drive, centrifugal fan, with power-induced outside air, **as directed**, and integral condensate pump.
  5. Fan Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - a. Special Motor Features: Multitapped, multispeed with internal thermal protection and permanent lubrication.
  6. Filters: Permanent, cleanable **OR** Disposable, with ASHRAE 52.2 MERV rating of 6 or higher, **as directed**.
- E. Air-Cooled, Compressor-Condenser Components
1. Casing: Steel, finished with baked enamel in color selected by the Owner, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
  2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
    - a. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
    - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
    - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
  3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins, complying with ARI 210/240, and with liquid subcooler.
  4. Heat Pump Components: Reversing valve and low-temperature air cut-off thermostat.
  5. Fan: Aluminum-propeller type, directly connected to motor.
  6. Motor: Permanently lubricated, with integral thermal-overload protection.
  7. Low Ambient Kit: Permits operation down to **45 deg F (7 deg C)**.
  8. Mounting Base: Polyethylene.
  9. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
- F. Water-Cooled, Compressor-Condenser Components

1. Casing: Steel, with baked-enamel finish in color selected by the Owner, removable panels for access to controls, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation. Compressor motor shall have thermal- and current-sensitive overload devices, start capacitor, relay, and contactor.
  - a. Compressor Type: Reciprocating **OR** Scroll, **as directed**.
  - b. Two-speed compressor motor with manual-reset high-pressure switch and automatic-reset low-pressure switch.
  - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
3. Heat Pump Components: Reversing valve.
4. Heat Exchanger: Copper tubes in copper tube or in steel shell, with water-temperature-actuated, water-regulating valve.
5. Minimum Energy Efficiency: Comply with ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."

G. Accessories

1. Control equipment and sequence of operation are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
2. Thermostat: Low voltage with subbase to control compressor and evaporator fan.
3. Thermostat: Wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
  - a. Compressor time delay.
  - b. 24-hour time control of system stop and start.
  - c. Liquid-crystal display indicating temperature, set-point temperature, time setting, operating mode, and fan speed.
  - d. Fan-speed selection, including auto setting.
4. Automatic-reset timer to prevent rapid cycling of compressor.
5. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
  - a. Minimum Insulation Thickness: **1/2 inch (13 mm) OR 1 inch (25 mm), as directed**, thick.

### 1.3 EXECUTION

A. Installation

1. Install units level and plumb.
2. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.
3. Install ground-mounting, compressor-condenser components on **4-inch- (100-mm-)** thick, reinforced concrete base; **4 inches (100 mm)** larger on each side than unit. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete". Coordinate anchor installation with concrete base.  
**OR**  
Install ground-mounting, compressor-condenser components on polyethylene mounting base.
4. Install roof-mounting compressor-condenser components on equipment supports specified in Division 07 Section "Roof Accessories". Anchor units to supports with removable, cadmium-plated fasteners.
5. Install seismic restraints.
6. Install compressor-condenser components on restrained, spring isolators with a minimum static deflection of **1 inch (25 mm)**. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
7. Install and connect precharged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  - a. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
  - b. Remote Water-Cooled Condenser Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
  - c. Steam Coil Connections: Comply with requirements in Division 23 Section "Steam And Condensate Heating Piping". Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.
2. Install piping adjacent to unit to allow service and maintenance.
3. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to split-system air-conditioning units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".
4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
5. Electrical Connections: Comply with requirements in Division 22 for power wiring, switches, and motor controls.

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
  - a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace malfunctioning units and retest as specified above.

D. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
  - a. Complete installation and startup checks according to manufacturer's written instructions.

E. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.

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Task	Specification	Specification Description
23 63 13 00	23 01 60 71	Condensing Units

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## SECTION 23 64 13 16 - DIRECT-FIRED ABSORPTION WATER CHILLERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for direct-fired absorption water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Packaged, water-cooled, direct-fired absorption chillers.
  - b. Heat-exchanger, brush-cleaning system.

#### C. Definitions

1. BAS: Building automation system.
2. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
3. IPLV: Integrated part-load value. A single-number, part-load efficiency figure of merit calculated per the method defined by ARI 560 and referenced to ARI standard rating conditions.
4. NPLV: Nonstandard part-load value. A single-number, part-load efficiency figure of merit calculated per the method defined by ARI 560 and intended for operating conditions other than the ARI standard rating conditions.

#### D. Performance Requirements

1. Seismic Performance: Direct-fired absorption chillers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
2. Condenser-Fluid Temperature Performance:
  - a. Startup Condenser-Fluid Temperature: Chiller shall be capable of starting with an entering condenser-fluid temperature of 60 deg F (16 deg C) and providing stable operation until the system temperature is elevated to the minimum operating entering condenser-fluid temperature.
  - b. Minimum Operating Condenser-Fluid Temperature: Chiller shall be capable of continuous operation over the entire capacity range indicated with an entering condenser-fluid temperature of 70 deg F (21 deg C).
  - c. Make factory modifications to standard chiller design if necessary to comply with performance indicated.
3. Site Altitude: Chiller shall be suitable for altitude at which it is installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.
4. Performance Tolerance: Comply with the following in lieu of ARI 560:
  - a. Allowable Capacity Tolerance: Zero percent.
  - b. Allowable IPLV/NPLV Performance Tolerance: Zero percent.

#### E. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties and accessories, and the following:
  - a. Performance at ARI standard conditions and at conditions indicated.
  - b. Performance at ARI standard unloading conditions.
  - c. Minimum evaporator flow rate.

- d. Absorbent capacity of chiller.
- e. Refrigerant capacity of chiller.
- f. Fluid capacity of evaporator and condenser.
- g. Fluid capacity of generator.
- h. Characteristics of safety relief devices.
- i. Minimum entering condenser-fluid temperature.
- j. Performance at varying capacities with constant design condenser-fluid temperature. Repeat performance at varying capacities for different condenser-fluid temperatures from design to minimum in 5 deg F (3 deg C) increments.
- k. If equipped, fluid capacity of dedicated hot-water heater exchanger.
- l. Combustion-air flow.
- m. Exhaust gas airflow.
- n. Exhaust gas minimum and maximum operating temperature.
2. LEED Submittals:
  - a. Product Data for Prerequisite EA 2: Documentation indicating that units comply with applicable requirements in ASHRAE/IESNA 90.1.
  - b. Product Data for Prerequisite EA 3: Documentation indicating that refrigerants comply.
  - c. Product Data for Credit EA 4: Documentation indicating that equipment and refrigerants comply.
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, load distribution, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
  - c. Insulated Surface Diagrams: Indicating cold and hot surfaces requiring field-applied insulation with area tabulated for each.
4. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
  - a. Structural supports.
  - b. Piping roughing-in requirements.
  - c. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
  - d. Access requirements, including working clearances for mechanical controls and electrical equipment, and clearances for tube pull and service.
5. Certificates: For certification required in "Quality Assurance" Article.
6. Seismic Qualification Certificates: For chillers, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Source quality-control reports.
8. Startup service reports.
9. Operation and Maintenance Data: For each chiller to include in emergency, operation, and maintenance manuals.
10. Warranty: Sample of special warranty.

F. Quality Assurance

1. ARI Rating: Rate chiller performance according to requirements in ARI 560.
2. ASHRAE Compliance:
  - a. ASHRAE 15 for safety code for mechanical refrigeration.
  - b. ASHRAE/IESNA 90.1.
3. ASME Compliance: Fabricate and label chiller pressure vessels to comply with applicable portions of ASME Boiler and Pressure Vessel Code.
4. Comply with NFPA 70.

5. Comply with requirements of UL and UL Canada, and include label by a qualified testing agency showing compliance.
  - a. UL Compliance: UL 726, "Oil-Fired Boiler Assemblies" **OR** UL 726, "Oil-Fired Boiler Assemblies"; and UL 795, "Commercial-Industrial Gas Heating Equipment" **OR** UL 795, "Commercial-Industrial Gas Heating Equipment", **as directed**.
- G. Delivery, Storage, And Handling
  1. Ship chillers factory charged with nitrogen.
  2. Ship absorbent and refrigerant in chillers or in containers separate from chillers.  
**OR**  
Ship absorbent and refrigerant in containers separate from chillers.
  3. Package chiller for export shipping in totally enclosed bagging **OR** crate **OR** crate with bagging, **as directed**.
- H. Coordination
  1. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
  2. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.
- I. Warranty
  1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of chillers that fail in materials or workmanship within specified warranty period.
    - a. Extended warranties include, but are not limited to, the following:
      - 1) Complete chiller.  
**OR**  
Pumps and motors **OR** Purge unit **OR** Burner assembly, **as directed**.  
**OR**  
Absorbent **OR** Absorbent and refrigerant, **as directed**, only.
      - 2) Parts only **OR** only and labor, **as directed**.
      - 3) Loss of absorbent and refrigerant for any reason.
    - b. Warranty Period: Two **OR** Three **OR** Four **OR** Five, **as directed**, years from date of Final Completion.

## 1.2 PRODUCTS

- A. Manufactured Unit
  1. Description: Factory-assembled and -tested, hermetic-design chiller complete with absorber, evaporator, condenser, generator, solution heat exchanger, controls, absorbent solution pump with motor, refrigerant pump with motor, purge unit with motor, burner assembly, motor controllers, rupture disk, interconnecting unit piping and wiring, indicated accessories, and mounting frame.
    - a. Disassemble chiller into major assemblies, as required by the installation, after factory testing and before packaging for shipment.
  2. Absorbent and Refrigerant:
    - a. Absorbent: Lithium bromide solution with corrosion inhibitor.
    - b. Refrigerant: Deionized or distilled, **as directed**, water.
    - c. Performance Enhancer: Heat and mass transfer enhancer to improve performance.
  3. Seismic Fabrication Requirements: Fabricate mounting base and attachment to chiller, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when mounting base is anchored to building structure.
- B. Pumps



1. Hermetically sealed, self-lubricating, and fitted with self-adjusting, spring-loaded, wear-compensating, tapered carbon bearings.
2. Pump motor assembly shall be designed to operate for not less than 50,000 hours between inspections.
3. Pump motors shall be cooled and bearings lubricated, either by fluid being pumped or by a filtered supply of liquid refrigerant.
4. Pump suction and discharge shall be equipped with isolation valves.
5. Absorbent solution and refrigerant shall have separate and dedicated pumps.
  - a. Absorbent solution and refrigerant flow-control method shall be manufacturer's choice to comply with operating requirements indicated.
6. Purge System: Unit mounted and factory wired, equipped with controls and a pump to automatically remove noncondensable vapors.
  - a. Purge Pump Motor: Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 1) Enclosure: Open dripproof **OR** Totally enclosed, **as directed**.

#### C. Heat-Exchanger Shells

1. Configuration: Two shells; one shell consists of the absorber/evaporator, low-stage generator/condenser and the other shell consists of the high-stage generator. Where indicated, equip chiller with a dedicated hot-water heat exchanger.
2. Construction: Fabricated from continuously welded carbon-steel sheet or plate, or from seamless pipe.
3. Design Pressure and Temperature Rating: Comply with applicable requirements in ASME Boiler and Pressure Vessel Code.
4. End Tube Sheets: Carbon-steel plates continuously welded to each end of shell; drilled and reamed to accommodate tubes, with positive seal between fluid in tubes and refrigerant in shell.
5. Intermediate Tube Sheets: Carbon-steel plates installed in shell and spaced along length of tube at intervals required to eliminate vibration and to avoid tube contact resulting in abrasion and wear.
6. Generator/Condenser Shell Pressure Relief Device: Manufacturer's standard rupture disk complying with requirements in ASHRAE 15 and in applicable portions of ASME Boiler and Pressure Vessel Code.

#### D. Absorber

1. Nozzle or Dispersion Trays: Designed to evenly distribute absorbent solution over tubes; constructed of brass, stainless steel, or another material that will not corrode.
2. Tubes:
  - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
  - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
  - c. Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm), as directed**.
  - d. External Finish: Manufacturer's standard.
  - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
3. Water Boxes:
  - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard **OR** Marine-type, **as directed**, water box with piping connections.
    - 1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
    - 2) Hinged **OR** Davited, **as directed**, water boxes.  
**OR**  
Hinged **OR** Davited, **as directed**, marine-type water-box covers.
  - c. Standard water box without piping connections.

- 1) Water boxes shall have lifting lugs or eyebolts.
  - 2) Hinged **OR** Davited, **as directed**, water boxes.
  - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - f. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
  4. Additional Corrosion Protection:
    - a. Electrolytic corrosion-inhibitor anode.
    - b. Coat wetted surfaces with a corrosion-resistant finish.

**OR**

Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.
  5. Absorber/Condenser Crossover Piping: Factory-furnished and -installed piping connecting fluid connection of absorber discharge to condenser inlet.
- E. Evaporator
1. Nozzle or Dispersion Trays: Designed to evenly distribute refrigerant over tubes; constructed of brass, stainless steel, or another material that will not corrode.
  2. Refrigerant Holding Pan: Steel or stainless steel.
  3. Tubes:
    - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
    - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
    - c. Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.
    - d. External Finish: Manufacturer's standard.
    - e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
  4. Water Boxes:
    - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
    - b. Standard **OR** Marine-type, **as directed**, water box with piping connections.
      - 1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
      - 2) Hinged **OR** Davited, **as directed**, water boxes.

**OR**

Hinged **OR** Davited, **as directed**, marine-type water-box covers.
    - c. Standard water box without piping connections.
      - 1) Water boxes shall have lifting lugs or eyebolts.
      - 2) Hinged **OR** Davited, **as directed**, water boxes.
    - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
    - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
    - f. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- F. Condenser
1. Refrigerant Holding Pan: Steel or stainless steel.
  2. Tubes:
    - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
    - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
    - c. Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.

- d. External Finish: Manufacturer's standard.
- e. Internal Finish: Enhanced **OR** Smooth, **as directed**.
- 3. Water Boxes:
  - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard **OR** Marine-type, **as directed**, water box with piping connections.
    - 1) Water boxes and marine-type water-box covers, **as directed**, shall have lifting lugs or eyebolts.
    - 2) Hinged **OR** Davited, **as directed**, water boxes.
  - OR**
  - c. Hinged **OR** Davited, **as directed**, marine-type water-box covers.
  - c. Standard water box without piping connections.
    - 1) Water boxes shall have lifting lugs or eyebolts.
    - 2) Hinged **OR** Davited, **as directed**, water boxes.
  - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - f. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- 4. Additional Corrosion Protection:
  - a. Electrolytic corrosion-inhibitor anode.
  - b. Coat wetted surfaces with a corrosion-resistant finish.
- OR**
- Using same material as tubes, clad surfaces of end tube sheets in contact with fluid. Coat other wetted surfaces, including water boxes, with a corrosion-resistant finish.

#### G. First-Stage Generator

- 1. Tubes:
  - a. Replaceable, **as directed**, straight, or U tubes expanded into tube sheets.
  - b. Material: Manufacturer's standard **OR** Steel, **as directed**.
  - c. Minimum Wall Thickness: Manufacturer's choice.
  - d. External Finish: Manufacturer's standard.
  - e. Internal Finish: Manufacturer's choice; enhanced or smooth.
- 2. Water Boxes:
  - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard water box.
  - c. Water boxes shall have lifting lugs or eyebolts.
  - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - f. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.

#### H. Second-Stage Generator

- 1. Tubes:
  - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
  - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
  - c. Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.
  - d. External Finish: Manufacturer's standard.
  - e. Internal Finish: Manufacturer's standard.



2. Water Boxes:
  - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
  - b. Standard type.
  - c. Water boxes shall have lifting lugs or eyebolts.
  - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
  - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
  - f. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- I. Dedicated Hot-Water Heat Exchanger
  1. Tubes:
    - a. Individually replaceable, straight tubes expanded into tube sheets. Replaceable from either end without damage to tube sheets and other tubes.
    - b. Material: Copper **OR** Copper-nickel alloy, **as directed**.
    - c. Minimum Wall Thickness: Manufacturer's choice **OR 0.025 inch (0.6 mm) OR 0.028 inch (0.7 mm) OR 0.035 inch (0.9 mm)**, **as directed**.
    - d. External Finish: Manufacturer's standard.
    - e. Internal Finish: Manufacturer's standard.
  2. Water Boxes:
    - a. Carbon-steel construction; arranged to provide visual inspection and cleaning of tubes from either end without disturbing refrigerant in shell.
    - b. Standard type.
    - c. Water boxes shall have lifting lugs or eyebolts.
    - d. Nozzle Pipe Connections: Welded, ASME B16.5, flat-face flange **OR** Welded, ASME B16.5, raised-face flange **OR** Grooved for mechanical-joint coupling **OR** Grooved with mechanical-joint coupling and flange adapter, **as directed**.
    - e. Thermistor or RTD temperature sensor factory installed in each nozzle.
    - f. Fit each water box with **3/4-inch (19-mm) OR 1-inch (25-mm)**, **as directed**, drain connection at low point and vent connection at high point, each with threaded plug.
- J. Solution Heat Exchanger
  1. Description: Shell-and-tube or brazed-plate heat exchanger, an integral part of chiller, increases cycle efficiency by preheating the weak solution on its way to the generator while precooling the strong solution returning from the generator.
- K. Burner Assembly
  1. Burner: Welded construction with multivane, stainless-steel, flame-retention diffuser suitable for natural gas **OR** propane **OR** fuel oil, **as directed**. Mount burner on hinged access door to permit access to combustion chamber, **as directed**.
  2. Blower: Centrifugal fan integral to burner, directly driven by motor; with adjustable damper assembly and locking quadrant to set air-fuel ratio.
    - a. Motors: Comply with requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
      - 1) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  3. Oil Supply: Control devices and modulating control sequence shall comply with requirements of ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
    - a. Oil Pump: Two-stage, gear-type oil pump shall be capable of producing **300-psig (2070-kPa)** discharge pressure and **15-in. Hg (50.7-kPa)** vacuum.
    - b. Oil Piping Specialties:
      - 1) Suction-line, manual, gate valve.
      - 2) Removable-mesh oil strainer.

- 3) 0- to 30-in. Hg (0- to 101.3-kPa) vacuum; 0- to 30-psig (0- to 207-kPa) vacuum-pressure gage.
- 4) 0- to 300-psig (0- to 2070-kPa) oil-nozzle pressure gage.
- 5) Nozzle-line, solenoid-safety-shutoff oil valve.
4. Oil Pilot: Intermittent-electric-spark **OR** Interrupted-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff solenoid with cadmium sulfide **OR** UV scanner, **as directed**, flame-safety control.
5. Gas Train: Control devices and modulating control sequence shall comply with requirements of ASME CSD-1 **OR** FMG **OR** IRI **OR** UL, **as directed**.
6. Gas Pilot: Intermittent-electric-spark **OR** Interrupted-electric-spark, **as directed**, pilot ignition with 100 percent main-valve and pilot-safety shutoff with electronic supervision of burner flame.
7. Burner assembly shall be equipped to limit nitrogen oxide emissions to 20 **OR** 30, **as directed**, ppm.

#### L. Electrical

1. Factory installed and wired, and functionally tested at factory before shipment.
2. Single-point, field-power connection to fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**. Minimum withstand rating shall be as required by electrical power distribution system, but not less than 42,000 **OR** 65,000, **as directed**, A.
  - a. Branch power circuit to each motor, dedicated electrical load, and to controls with disconnect switch or circuit breaker, **as directed**.
    - 1) NEMA KS 1, heavy-duty fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - 2) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit-trip set point.
  - b. NEMA ICS 2, Class A, full-voltage, nonreversing motor controller, hand-off-auto switch, and overcurrent protection for each motor.
  - c. Control-circuit transformer with primary and secondary side fuses.
3. Terminal blocks with numbered and color-coded, **as directed**, wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
4. Wiring Outside of Enclosures: Factory installed in metal raceway except make terminal connections with not more than a 24-inch (610-mm) length of liquidtight **OR** flexible metallic, **as directed**, conduit.

#### M. Controls

1. Chiller control panel shall be separate from burner control panel.
2. Burner Control Panel: Factory or field, **as directed**, mounted. Maintains safe operating conditions, burner safety limits, burner operation, and interface with chiller controls; include the following components:
  - a. On-off switch.
  - b. Flame safeguard.
  - c. Contacts for remote monitoring of flame failure.
  - d. Contacts for proof of combustion air.
  - e. Exhaust gas temperature limit switch.
  - f. Control-circuit transformer.
  - g. Burner motor controls.
  - h. Fuel-oil pump controls, if chiller is equipped with fuel-oil pump.
  - i. Visual indication of on/off status of ignition, blower, and main fuel.
  - j. Alarm bell.
3. Control: Standalone and microprocessor based, with all memory stored in nonvolatile memory so that reprogramming is not required on loss of electrical power.
4. Enclosure: Unit mounted, NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x, **as directed**, hinged or lockable.

5. Operator Interface: Multiple-character digital or graphic display with dynamic update of information and with keypad or touch-sensitive display located on front of control enclosure. Display the following information in either imperial or metric units selectable through the interface:
  - a. Date and time.
  - b. Operating or alarm status.
  - c. Operating hours.
  - d. Outdoor-air temperature if required for chilled-water reset.
  - e. Temperature and pressure of operating set points.
  - f. Entering and leaving temperatures of chilled and condenser water.
  - g. Refrigerant temperature.
  - h. Solution concentration and temperature.
  - i. Indication of solution and purge-pump operation.
  - j. Generator shell pressure.
  - k. Number of starts.
  - l. Number of purge cycles.
  - m. Entering and leaving hot-water temperatures.
  - n. Burner firing rate displayed in percent.
6. Control Functions:
  - a. Manual or automatic startup and shutdown time schedule.
  - b. Automatic cycle to prevent crystallization.
  - c. Entering and leaving chilled-water temperatures and control set points. Chilled-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
  - d. Entering and leaving hot-water temperatures and control set points. Hot-water temperature shall be reset based on return-water **OR** outdoor-air **OR** space, **as directed**, temperature.
  - e. Condenser-fluid temperature.
  - f. Cooling provided and heating energy used within programmable time periods, minimum monthly.
  - g. Heating provided and heating energy used within programmable time periods, minimum monthly.
7. Capacity Control: Automatically controls burner firing rate to maintain chilled-water temperature set point for cooling loads and heating-water temperature set point for heating loads ranging from 30 to 100 percent.
8. Safety Shutdowns: Chiller shall automatically shut down and require manual restart. Display a message following each safety shutdown.
  - a. Crystallization.
  - b. Low refrigerant temperature.
  - c. Loss of chilled- or condenser-water flow.
  - d. Low leaving chilled-water temperature, **2 deg F (1 deg C)** below set point.
  - e. First-stage generator low-solution level.
  - f. First-stage generator high temperature or pressure.
  - g. Burner alarm or control malfunction.
  - h. Power failure.
  - i. Solution pump overloads.
  - j. External auxiliary safety shutdown.
  - k. High solution concentration.
  - l. Incomplete dilution cycle.
9. Warning Conditions: Chiller shall remain operational but inhibit burner firing rate to prevent safety shutdown. Control panel shall close warning contacts and generate a message when one of the following operating conditions is detected:
  - a. Low refrigerant temperature.
  - b. High generator temperature or pressure.
  - c. High or low entering condenser-water temperature.
  - d. Solution temperature sensor failure.
  - e. Low chilled-water flow.

- f. Purge-pump current overload.
  - 10. Cycling Shutdowns: Permit automatic restart when preprogrammed limits are reached. Display a message following each cycle shutdown.
    - a. Cooling Mode:
      - 1) Loss of condenser-water flow.
      - 2) Low leaving chilled-water temperature.
      - 3) Power failure.
    - b. Heating Mode:
      - 1) Loss of hot-water flow.
      - 2) High leaving hot-water temperature.
      - 3) Power failure.
  - 11. Trending: Capability to trend analog data up to five parameters simultaneously over an adjustable period and frequency of polling.
  - 12. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: view only; view and operate; and view, operate, and service.
  - 13. Control Authority: At least four conditions: Off, local manual control at chiller, local automatic control at chiller, and automatic control through a remote source.
  - 14. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.
  - 15. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display chiller status and alarms.
    - a. Hardwired Points:
      - 1) Monitoring: On-off status, common trouble alarm.
      - 2) Control: On-off operation, chilled-water, discharge temperature set-point adjustment **OR** hot-water, discharge temperature set-point adjustment, **as directed**.
    - b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the chiller from an operator workstation. Control features and monitoring points displayed locally at chiller control panel shall be available through the BAS.
- N. Finish
- 1. Paint chiller, using manufacturer's standard procedures, except comply with the following minimum requirements:
    - a. Provide at least one coat of primer with a total dry film thickness of at least **2 mils (0.05 mm)**.
    - b. Provide at least two coats of alkyd-modified, vinyl enamel **OR** epoxy **OR** polyurethane, **as directed**, finish with a total dry film thickness of at least **4 mils (0.10 mm)**.
    - c. Paint surfaces that are to be insulated before applying the insulation.
    - d. Paint installed insulation to match adjacent uninsulated surfaces.
    - e. Color of finish coat to be manufacturer's standard **OR** custom color selected by the Owner.
- O. Accessories
- 1. Sight Glasses: Equip unit with sight glasses for visual inspection of absorbent solution and refrigerant levels. Provide at least one sight glass in absorber and evaporator sections.
  - 2. Flow Switches:
    - a. Chiller manufacturer shall furnish a switch for each condenser **OR** evaporator and condenser, **as directed**, and shall verify field-mounting location before installation.
    - b. Paddle Flow Switches:
      - 1) Vane operated to actuate a double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
      - 2) Contacts: Platinum alloy, silver alloy, or gold-plated switch contacts with a rating of 10 A at 120-V ac.
      - 3) Pressure rating equal to pressure rating of heat exchanger.

- 4) Construct body and wetted parts of Type 316 stainless steel.
- 5) House switch in an NEMA 250, Type 4 enclosure constructed of die-cast aluminum.
- 6) Vane length to suit installation.
- c. Pressure Differential Switches:
  - 1) Construction: Wetted parts of body and trim constructed of Type 316 stainless steel.
  - 2) Performance: Switch shall withstand, without damage, the full-pressure rating of the heat exchanger applied to either port and exhibit zero set point shift due to variation in working pressure.
  - 3) Set Point: Screw type, field adjustable.
  - 4) Electrical Connections: Internally mounted, screw-type terminal blocks.
  - 5) Switch Enclosure: NEMA 250, Type 4.
  - 6) Switch Action: Double-pole, double-throw switch with one pole field wired to the chiller control panel and the other pole field wired to the BAS.
3. Vibration Isolation:
  - a. Chiller manufacturer shall furnish neoprene-pad vibration isolation for each chiller.
    - 1) Two layers of **0.375-inch- (10-mm-)** thick, ribbed- or waffle-pattern neoprene pads separated by a 16-gage, stainless-steel plate.
    - 2) Fabricate pads from 40- to 50-durometer neoprene.
    - 3) Provide stainless-steel square bearing plate to load the pad uniformly between **20 and 40 psig (138 and 276 kPa)** with a **0.12- to 0.16-inch (3- to 4-mm)** deflection.
- P. Heat-Exchanger, Brush-Cleaning System
  1. Furnish for field installation a brush-cleaning system on each chiller condenser for tube cleaning and improved heat transfer.
  2. System shall maintain tube fouling at or below design conditions without interrupting normal equipment operation.
  3. System shall consist of a brush inserted in each tube and a catch basket attached to each end of the tube. A four-way valve shall operate to reverse the direction of water flow to push the brush through the tube while removing tube deposits. Four-way reversing valve's actuator shall be controlled by a preset time cycle that provides regular tube brushing during equipment operation. Frequency of the brushing cycle shall be set up to match Project requirements.
  4. Components:
    - a. Brush: Each brush shall have nylon bristles, titanium wires, and polypropylene tips. Brush interference fit with the ID of the tube shall not exceed **0.025 inch (0.6 mm)**.
    - b. Basket: Single-piece polypropylene basket with neck OD to press fit inner diameter of tube. Design shall provide for insertion of eddy current probe or removal of brushes without removing baskets from the valve.
    - c. Four-Way Valve:
      - 1) Construct valve body of carbon steel with internal sealing parts of hard rubber and Type 304 stainless steel.
      - 2) Configure valve with parallel flow connections to minimize field installation piping.
      - 3) Construct valve to comply with ASME Boiler and Pressure Vessel Code , at a system working pressure equal to condenser.
      - 4) Pipe connections shall be flanged.
      - 5) Valve manufacturer to test and certify a maximum leakage rate of less than 0.05 percent of the design flow rate at operation conditions of maximum differential pressure.
      - 6) Hydrostatically test valve to 1.5 times the design working pressure.
      - 7) Design the valve to cause no more than **0.5-psig (3-kPa)** pressure drop at design flow conditions.
      - 8) Provide valve with valve-mounted indicating/warning light, which shall light before the valve begins rotation.
      - 9) Valve Actuator: Mount electric actuator to operate valve.

**OR**

Valve Actuator: Mount pneumatic piston-type actuator to operate valve. Actuator shall be suitable for operation using field-supplied air pressure.





- 10) Position Switches: Factory mount microswitches on valve to indicate the complete turn of valve in both normal and reverse flow.
- d. Control Panel: Factory or field mount a control panel on chiller. Control panel shall include the following features:
  - 1) NEMA 250, Type 1 **OR** Type 4 **OR** Type 4x **OR** Type 12, **as directed**, enclosure.
  - 2) Timer to automatically initiate the cleaning cycle over a 24-hour period.
  - 3) Manual override of preset cleaning cycle.
  - 4) Visual indication of "Power On," "Diverter Position," "Normal Flow," "Reverse Flow," and "Valve Malfunction" indicating a slow or incomplete valve turn.
  - 5) For pneumatic actuators, mount four-way solenoid valve for actuator operation in the control panel.
  - 6) Flow-switch bypass.
  - 7) Unloading signal to chiller.

Q. Source Quality Control

1. Perform functional run tests of chillers before shipping.
2. Factory test and inspect absorber, generator, evaporator, and condenser according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Pressure test tube-side of heat exchangers, including water boxes, to 1.5 times the rated pressure. Vacuum and pressure test shells for leaks.
3. Rate sound power level according to ARI 575.
4. Burner Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion requirements indicated.
5. Factory performance test chillers, before shipping, according to ARI 560.
  - a. Test the following conditions:
    - 1) Design conditions indicated.
    - 2) Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with condenser fluid at design conditions.  
**OR**  
 Reduction in capacity from design to minimum load in steps of 10 **OR** 25 **OR** 33, **as directed**, with varying entering condenser-fluid temperature from design to minimum conditions in 5 deg F (3 deg C) increments.  
**OR**  
 At one **OR** two **OR** three **OR** four **OR** five **OR** 10, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
6. Factory sound test chillers, before shipping, according to ARI 575.
  - a. Test the following conditions:
    - 1) Design conditions indicated.
    - 2) Chiller operating at calculated worst-case sound condition.
    - 3) At one **OR** two **OR** three **OR** four **OR** five, **as directed**, point(s) of varying part-load performance to be selected by the Owner at time of test.
7. Allow the Owner access to place where chillers are being tested. Notify the Owner 14 days in advance of testing.
8. Prepare test report indicating test procedures, instrumentation, test conditions, and results. Submit copy of results within one week of test date.

### 1.3 EXECUTION

A. Examination

1. Examine chillers before installation. Reject chillers that are damaged.
2. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

- a. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
  3. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Chiller Installation
1. Install chillers on support structure indicated.
  2. Equipment Mounting (for equipment supported on concrete bases and vibration isolation devices): Install chiller on concrete bases using elastomeric pads. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
    - a. Minimum Deflection: **1/4 inch (6 mm) OR 1/2 inch (13 mm), as directed.**
    - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
    - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
    - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
  3. Equipment Mounting (for equipment supported on vibration isolation devices without a concrete base): Install chiller using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
    - a. Minimum Deflection: **1/4 inch (6 mm) OR 1/2 inch (13 mm), as directed.**
  4. Equipment Mounting (for equipment installed on concrete bases without vibration isolation devices): Install chiller on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
    - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
    - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
    - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
  5. Install chillers with seismic-restraint device. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  6. Install seismic restraints on piping. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  7. Maintain manufacturer's recommended clearances for service and maintenance.
  8. Charge chiller with absorbent and refrigerant if not factory charged.
  9. Install separate devices furnished by manufacturer and not factory installed.
  10. Insulate hot and cold chiller surfaces that are recommended by chiller manufacturer to be insulated. Comply with requirements in Division 23 Section "Hvac Insulation".
  11. Install electrical devices furnished with chiller but not specified to be factory mounted.
  12. Install control wiring to field-mounted electrical devices.
- C. Heat-Exchanger, Brush-Cleaning System Installation
1. Install brush-cleaning system control panel adjacent to chiller control panel.
  2. Arrange piping to provide service access to four-way valve assembly without affecting access to chiller. Secure valve to prevent lateral movement and vibration during operation.
  3. Provide field electric power, as required, to each system control panel and electric-actuated valve.





4. Provide pneumatic piping with pressure regulator and an isolation valve to each pneumatic supply connection. Coordinate field source of air with manufacturer to ensure that requirements are satisfied for proper valve operation.
5. Interconnect brush-cleaning system controls with chiller controls. Coordinate requirements to ensure safe, trouble-free operation.
6. Functionally test the entire brush-cleaning system, including the valve, actuator, position indicator, and control panel, with chiller in operation.

#### D. Connections

1. Comply with requirements for hydronic piping in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements for gas piping in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Connect gas piping full size to gas-train inlet with shutoff valve and union.
4. Install gas-fired boilers according to NFPA 54.
5. Comply with requirements for fuel-oil piping in Division 23 Section "Facility Fuel-oil Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
6. Connect oil piping full size to burner inlet with shutoff valve and union.
7. Install oil-fired boilers according to NFPA 31.
8. Install piping adjacent to chiller to allow service and maintenance.
9. Hot-Water Heat-Exchanger Connections: Connect to heat-exchanger inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to heat-exchanger outlet with shutoff valve, check valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
10. Evaporator-Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
11. Absorber/Condenser-Fluid Connections: Connect to inlet with shutoff valve, strainer, flexible connector, thermometer, and plugged tee with shutoff valve and pressure gage. Connect to outlet with shutoff valve, balancing valve, flexible connector, flow switch, thermometer, plugged tee with shutoff valve and pressure gage, flow meter, and drain connection with valve. Make connections to chiller with a flange or mechanical coupling.
  - a. If not factory furnished or installed, provide pipe connecting fluid connection of absorber discharge and condenser inlet.
12. Refrigerant Pressure Relief Device Connections: Extend vent piping **OR** separate vent piping for each chiller, **as directed**, to the outdoors without valves or restrictions. Comply with ASHRAE 15. Connect to chiller pressure relief device with flexible connector and dirt leg with drain valve.
13. Extend purge vent piping **OR** separate purge vent piping for each chiller, **as directed**, to the outdoors. Comply with ASHRAE 15.
14. Connect each chiller drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection.
15. Comply with requirements for chimney system in Division 23 Section "Breechings, Chimneys, And Stacks". Drawings indicate general arrangement of pipe, fittings, and specialties. Connect chimney system to chiller burner outlet and extend to the outdoors.
16. Connect fuel-fired burner assembly and blower and associated damper for combustion air.

#### E. Startup Service

1. Perform startup service.
  - a. Complete installation and startup checks according to manufacturer's written instructions.

- b. Operate chiller for run-in period.
  - c. Verify that absorbent and refrigerant charge is sufficient and chiller has been leak tested.
  - d. Verify that pumps are installed and functional.
  - e. Verify that thermometers and gages are installed.
  - f. Operate chiller for run-in period.
  - g. Verify that refrigerant pressure relief device is vented to the outdoors.
  - h. Verify proper motor rotation.
  - i. Verify proper fuel supply. Adjust air-fuel ratio and combustion.
  - j. Verify proper combustion-air source.
  - k. Verify proper exhaust emissions.
  - l. Verify static deflection of vibration isolators including deflection during chiller startup and shutdown.
  - m. Verify and record performance of fluid flow and low-temperature interlocks for evaporator and condenser.
  - n. Verify and record performance of chiller protection devices.
  - o. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
  - p. Burner Test: Adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas.
  - 2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.
  - 3. Prepare test and inspection startup reports.
- F. Demonstration
- 1. Train the Owner's maintenance personnel to adjust, operate, and maintain chillers. Video record the training sessions, **as directed**.

END OF SECTION 23 64 13 16

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Task	Specification	Specification Description
23 64 13 16	23 62 13 00	Indirect-Fired Absorption Water Chillers

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## SECTION 23 64 16 16 - FAN-COIL UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for fan-coil units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes fan-coil units and accessories.

#### C. Definitions

1. BAS: Building automation system.

#### D. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - a. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that fan-coil units, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

#### F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
  - a. Failures include, but are not limited to, the following:
    - 1) Compressor failure.
    - 2) Condenser coil leak.
  - b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Final Completion.
  - c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Final Completion.



- d. Warranty Period (Condenser Coil Only): Five years from date of Final Completion.

## 1.2 PRODUCTS

### A. Fan-Coil Units

1. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
2. Coil Section Insulation: **1/2-inch (13-mm) OR 1-inch (25-mm), as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
  - a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
  - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Main and Auxiliary Drain Pans: Plastic **OR** Stainless steel **OR** Insulated galvanized steel with plastic liner, **as directed**. Fabricate pans and drain connections to comply with ASHRAE 62.1. Drain pans shall be removable, **as directed**.
4. Chassis: Galvanized steel where exposed to moisture. Floor-mounting units shall have leveling screws.
5. Cabinet: Steel with factory prime coating, ready for field painting **OR** baked-enamel finish in manufacturer's standard paint color as selected by the Owner **OR** baked-enamel finish in manufacturer's custom paint color as selected by the Owner, **as directed**.
  - a. Vertical Unit Front Panels: Removable, steel, with integral stamped **OR** polyethylene **OR** steel, **as directed**, discharge grille and channel-formed edges, cam fasteners, and insulation on back of panel.
  - b. Horizontal Unit Bottom Panels: Fastened to unit with cam fasteners and hinge and attached with safety chain; with integral stamped **OR** cast-aluminum, **as directed**, discharge grilles.
  - c. Stack Unit Discharge and Return Grille: Aluminum double-deflection discharge grille, and louvered- or panel-type return grille; color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors. Return grille shall provide maintenance access to fan-coil unit.
  - d. Steel recessing flanges for recessing fan-coil units into ceiling or wall.
6. Outdoor-Air Wall Box: Minimum **0.1265-inch- (3.2-mm-)** thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
  - a. Louver Configuration: Horizontal **OR** Vertical, **as directed**, rain-resistant louver.
  - b. Louver Material: Aluminum **OR** Steel, **as directed**.
  - c. Bird Screen: **1/2-inch (13-mm)** mesh screen on interior side of louver.
  - d. Decorative Grille: On outside of intake.
  - e. Finish: Anodized aluminum **OR** Baked enamel, **as directed**, color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.
7. Outdoor-Air Damper: Galvanized-steel blades with edge and end seals and nylon bearings; with electronic **OR** pneumatic, **as directed**, two-position **OR** modulating, **as directed**, actuators.
8. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
  - a. Washable Foam: 70 percent arrestance and 3 MERV.
  - b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
  - c. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
9. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **200 psig (1378 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain valve.



10. Steam Coils: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **75 psig (517 kPa)**.
11. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
12. Fan and Motor Board: Removable.
  - a. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels, and aluminum, painted-steel, or galvanized-steel fan scrolls.
  - b. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - c. Wiring Termination: Connect motor to chassis wiring with plug connection.
13. Factory, Hydronic Piping Package: **ASTM B 88, Type L (ASTM B 88M, Type B) OR ASTM B 88, Type M (ASTM B 88M Type C)**, **as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
  - a. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for dual-temperature coil.
  - b. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
  - c. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for heating coil.
  - d. Two **OR** Three, **as directed**, -way two-position **OR** modulating, **as directed**, control valve for hot-water reheat coil.
  - e. Hose Kits: Minimum **400-psig (2758-kPa)** working pressure, and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
    - 1) Length: **24 inches (600 mm) OR 36 inches (900 mm)**, **as directed**.
    - 2) Minimum Diameter: Equal to fan-coil-unit connection size.
  - f. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and **600-psig (4140-kPa)** minimum CWP rating and blowout-proof stem.
  - g. Calibrated-Orifice Balancing Valves: Bronze body, ball type; **125-psig (860-kPa)** working pressure; **250-deg F (121-deg C)** maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
  - h. Automatic Flow-Control Valve: Brass or ferrous-metal body; **300-psig (2070-kPa)** working pressure at **250 deg F (121 deg C)**, with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
  - i. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); **125-psig (860-kPa)** working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum **NPS 1/2 (DN 15)** hose-end, full-port, ball-type blowdown valve in drain connection.
  - j. Wrought-Copper Unions: ASME B16.22.
  - k. Risers: **ASTM B 88, Type L (ASTM B 88M, Type B) OR ASTM B 88, Type M (ASTM B 88M Type C)**, **as directed**, copper pipe with hose and ball valve for system flushing.
14. Control devices and operational sequences are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
15. Basic Unit Controls:
  - a. Control voltage transformer.
  - b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features:
    - 1) Heat-cool-off switch.
    - 2) Fan on-auto switch.
    - 3) Fan-speed switch.



- 4) Manual **OR** Automatic, **as directed**, changeover.
  - 5) Adjustable deadband.
  - 6) Concealed **OR** Exposed, **as directed**, set point.
  - 7) Concealed **OR** Exposed, **as directed**, indication.
  - 8) Degree F **OR** Degree C, **as directed**, indication.
  - c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
    - 1) Concealed **OR** Exposed, **as directed**, set point.
    - 2) Concealed **OR** Exposed, **as directed**, indication.
  - d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
  - e. Unoccupied-period-override push button.
  - f. Data entry and access port.
    - 1) Input data includes room temperature, and humidity set points and occupied and unoccupied periods.
    - 2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
16. DDC, **as directed**, Terminal Controller:
- a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
  - b. Unoccupied Period Override Operation: Two, **as directed**, hours.
  - c. Unit Supply-Air Fan Operation:
    - 1) Occupied Periods: Fan runs continuously.
    - 2) Unoccupied Periods: Fan cycles to maintain room setback temperature.
  - d. Hydronic-Cooling-Coil Operation:
    - 1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to maintain room temperature.
    - 2) Unoccupied Periods: Close control valve.
  - e. Heating-Coil Operation:
    - 1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
    - 2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
  - f. Dual-Temperature Hydronic-Coil Operation:
    - 1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open control valve if temperature falls below thermostat set point.
    - 2) Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.
  - g. Reheat-Coil Operation:
    - 1) Humidity Control for Occupied Periods:
      - a) Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As space temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
    - 2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
    - 3) Occupied Periods:
      - a) Heating Operations: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
      - b) Humidity-Control Operations: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide

- heating. As space temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
- 4) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature. Humidity control is not available.
  - h. Outdoor-Air Damper Operation:
    - 1) Occupied Periods: Open damper to fixed position for 25 percent outdoor air.
    - 2) Unoccupied periods: Close damper.
  - i. Outdoor-Air Damper Operation:
    - 1) Occupied Periods:
      - a) Outdoor-Air Temperature below Room Temperature: If room temperature is above thermostat set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below thermostat set point, position damper to fixed minimum position.
      - b) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for 25 percent outdoor air.
    - 2) Unoccupied Periods: Close damper.
  - j. Controller shall have volatile-memory backup.
  17. BAS Interface Requirements:
    - a. Interface relay for scheduled operation.
    - b. Interface relay to provide indication of fault at the central workstation.
    - c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
      - 1) Adjust set points.
      - 2) Fan-coil-unit start, stop, and operating status.
      - 3) Data inquiry, including outdoor-air damper position, **as directed**, supply- and room-air temperature and humidity, **as directed**.
      - 4) Occupied and unoccupied schedules.
  18. Electrical Connection: Factory wire motors and controls for a single electrical connection.
- B. Ducted Fan-Coil Units
1. Description: Factory-packaged and -tested units rated according to ARI 440, ASHRAE 33, and UL 1995.
  2. Coil Section Insulation: **1/2-inch (13-mm) OR 1-inch (25-mm), as directed**, thick coated **OR** foil-faced, **as directed**, glass fiber complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
    - a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
    - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  3. Drain Pans: Plastic **OR** Stainless steel **OR** Insulated galvanized steel with plastic liner, **as directed**. Fabricate pans and drain connections to comply with ASHRAE 62.1.
  4. Chassis: Galvanized steel where exposed to moisture, with baked-enamel finish and removable access panels.
  5. Cabinets: Steel with baked-enamel finish in manufacturer's standard paint color.
    - a. Supply-Air Plenum: Sheet metal plenum finished and insulated to match the chassis with mill-finish, aluminum, double-deflection grille, **as directed**.
    - b. Return-Air Plenum: Sheet metal plenum finished to match the chassis.
    - c. Mixing Plenum: Sheet metal plenum finished and insulated to match the chassis with outdoor- and return-air, formed-steel dampers.
    - d. Dampers: Galvanized steel with extruded-vinyl blade seals, flexible-metal jamb seals, and interlocking linkage.
  6. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
    - a. Washable Foam: 70 percent arrestance and 3 MERV.

- b. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
- c. Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
- 7. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **200 psig (1378 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain.
- 8. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum **450 psig (3105 kPa)** for a minimum **300-psig (2070-kPa)** working pressure. Include thermal expansion valve.
- 9. Steam Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **75 psig (517 kPa)**.
- 10. Electric-Resistance Heating Coils: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
- 11. Direct-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, multispeed motor resiliently mounted in the fan inlet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
- OR**
- Belt-Driven Fans: Double width, forward curved, centrifugal; with permanently lubricated, single-speed motor installed on an adjustable fan base resiliently mounted in the cabinet. Aluminum or painted-steel wheels, and painted-steel or galvanized-steel fan scrolls.
- a. Motors: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- 12. Factory, Hydronic Piping Package: **ASTM B 88, Type L (ASTM B 88M, Type B) OR ASTM B 88, Type M (ASTM B 88M Type C), as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet.
  - a. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
  - b. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for heating coil.
  - c. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for dual-temperature coil.
  - d. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for reheat coil.
  - e. Hose Kits: Minimum **400-psig (2758-kPa)** working pressure, and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
    - 1) Length: **24 inches (600 mm) OR 36 inches (900 mm), as directed**.
    - 2) Minimum Diameter: Equal to fan-coil-unit connection size.
  - f. Two-Piece Ball Valves: Bronze body with full-port, chrome-plated bronze ball; PTFE or TFE seats; and **600-psig (4140-kPa)** minimum CWP rating and blowout-proof stem.
  - g. Calibrated-Orifice Balancing Valves: Bronze body, ball type; **125-psig (860-kPa)** working pressure, **250 deg F (121 deg C)** maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.
  - h. Automatic Flow-Control Valve: Brass or ferrous-metal body; **300-psig (2070-kPa)** working pressure at **250 deg F (121 deg C)**; with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of **2 to 80 psig (13.8 to 552 kPa)**.
  - i. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); **125-psig (860-kPa)** working pressure, with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum **NPS 1/2 (DN 15)** hose-end, full-port, ball-type blowdown valve in drain connection.
  - j. Wrought-Copper Unions: ASME B16.22.

13. Remote condensing units are specified in Division 23 Section "Packaged Compressor And Condenser Units".
14. Remote Condensing Units: Factory assembled and tested, consisting of compressors, condenser coils, fans, motors, refrigerant receiver, and operating controls. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
  - a. Casing: Steel with baked-enamel finish, removable panels for access to controls, weep holes for water drainage, and mounting holes in base.
  - b. Compressor: Hermetic, scroll **OR** reciprocating, **as directed**, type; internally isolated for vibration with factory-installed safety devices as follows:
    - 1) Antirecycle timer.
    - 2) High-pressure cutout.
    - 3) Low-pressure cutout or loss-of-charge switch.
    - 4) Internal thermal-overload protection.
    - 5) Current and voltage sensitive safety devices.
  - c. Compressor Motor: Start capacitor, relay, and contactor. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - d. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
  - e. Refrigerant Piping Materials: ASTM B 743 copper tube with wrought-copper fittings and brazed joints.
  - f. Refrigerant: R-407C **OR** R-410A, **as directed**.
  - g. Low ambient controls to permit operation down to **45 deg F (7 deg C)**.
  - h. Crankcase heater.
  - i. Charging and service fittings on exterior of casing.
  - j. Filter dryer.
  - k. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat operation.
  - l. Hot-gas-bypass, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
  - m. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
  - n. Condenser Fan: Direct-drive, aluminum propeller fan.
    - 1) Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - o. Accessories: Polyethylene mounting base to provide a permanent foundation.
15. Control devices and operational sequence are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".
16. Basic Unit Controls:
  - a. Control voltage transformer.
  - b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
    - 1) Heat-cool-off switch.
    - 2) Fan on-auto switch.
    - 3) Fan-speed switch.
    - 4) Manual **OR** Automatic, **as directed**, changeover.
    - 5) Adjustable deadband.
    - 6) Concealed **OR** Exposed, **as directed**, set point.
    - 7) Concealed **OR** Exposed, **as directed**, indication.
    - 8) Degree F **OR** Degree C, **as directed**, indication.
  - c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
    - 1) Concealed **OR** Exposed, **as directed**, set point.
    - 2) Concealed **OR** Exposed, **as directed**, indication.
  - d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
  - e. Unoccupied-period-override push button.
  - f. Data entry and access port.
    - 1) Input data includes room temperature, and humidity set points and occupied and unoccupied periods.





- 2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
17. DDC, **as directed**, Terminal Controller:
  - a. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
  - b. Unoccupied Period Override Operation: Two, **as directed**, hours.
  - c. Unit Supply-Air Fan Operation:
    - 1) Occupied Periods: Fan runs continuously.
    - 2) Unoccupied Periods: Fan cycles to maintain room setback temperature.
  - d. Hydronic-Cooling-Coil Operation:
    - 1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to maintain room temperature.
    - 2) Unoccupied Periods: Close control valve.
  - e. Refrigerant-Coil Operation:
    - 1) Occupied Periods: Start compressor to maintain room temperature or humidistat set point.
    - 2) Unoccupied Periods: Stop compressor cooling and cycle compressor for heating to maintain setback temperature.
  - f. Supplemental, **as directed**, Heating-Coil Operation:
    - 1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
    - 2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
    - 3) Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below **25 deg F (4 deg C)**.
  - g. Dual-Temperature Hydronic-Coil Operation:
    - 1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open **OR** modulate, **as directed**, control valve if temperature falls below thermostat set point.
    - 2) Unoccupied Periods: When chilled water is available, close valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.
  - h. Reheat-Coil Operation:
    - 1) Humidity Control for Occupied Periods: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
    - 2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
    - 3) Occupied Periods:
      - a) Heating Operations: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
      - b) Humidity-Control Operations: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
    - 4) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature. Humidity control is not available.
  - i. Outdoor-Air Damper Operation (for fixed, minimum outdoor-air intake):
    - 1) Occupied Periods: Open damper to fixed position for 25 percent outdoor air.

- 2) Unoccupied Periods: Close damper.
- j. Outdoor-Air Damper Operation (for outdoor-air economizer cycle based on temperature):
  - 1) Occupied Periods:
    - a) Outdoor-Air Temperature below Room Temperature: If room temperature is above room-temperature set point, modulate outdoor- and return-air dampers to maintain room-temperature set point (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum setting.
    - b) Outdoor-Air Temperature above Room Temperature: Position damper to fixed minimum position for 25 percent outdoor air.
  - 2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- k. Outdoor-Air Damper Operation (for outdoor-air economizer cycle based on enthalpy):
  - 1) Occupied Periods:
    - a) Outdoor-Air Enthalpy below Room Enthalpy: If room temperature is above room-temperature set point, modulate outdoor-air damper to maintain room temperature (outdoor-air economizer). If room temperature is below set point, position damper to fixed minimum position for 25 percent outdoor air.
    - b) Outdoor-Air Enthalpy above Room Enthalpy: Position damper to fixed minimum position for 25 percent outdoor air.
  - 2) Unoccupied Periods: Close outdoor-air damper and open return-air damper.
- l. Controller shall have volatile-memory backup.
- 18. BAS Interface Requirements:
  - a. Interface relay for scheduled operation.
  - b. Interface relay to provide indication of fault at the central workstation.
  - c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
    - 1) Adjust set points.
    - 2) Fan-coil-unit start, stop, and operating status.
    - 3) Data inquiry including outdoor-air damper position,, **as directed** supply- and room-air temperature and humidity, **as directed**.
    - 4) Occupied and unoccupied schedules.
- 19. Electrical Connection: Factory wire motors and controls for a single electrical connection.

### 1.3 EXECUTION

#### A. Installation

- 1. Install fan-coil units level and plumb.
- 2. Install fan-coil units to comply with NFPA 90A.
- 3. Suspend fan-coil units from structure with elastomeric hangers. Vibration isolators are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- 4. Verify locations of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices **48 inches (1220 mm) OR 60 inches (1525 mm)**, **as directed**, above finished floor.
- 5. Install new filters in each fan-coil unit within two weeks after Final Completion.

#### B. Connections

- 1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  - a. Install piping adjacent to machine to allow service and maintenance.
  - b. Connect piping to fan-coil-unit factory hydronic piping package. Install piping package if shipped loose.
  - c. Connect condensate drain to indirect waste.
    - 1) Install condensate trap of adequate depth to seal against the pressure of fan. Install cleanouts in piping at changes of direction.



2. Connect supply and return ducts to fan-coil units with flexible duct connectors specified in Division 23 Section "Air Duct Accessories". Comply with safety requirements in UL 1995 for duct connections.
3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
  - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
  - c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace malfunctioning units and retest as specified above.

D. Adjusting

1. Adjust initial temperature and humidity set points.
2. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

E. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan-coil units.

END OF SECTION 23 64 16 16



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Task	Specification	Specification Description
23 64 16 16	23 61 16 00	Centrifugal Water Chillers

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## SECTION 23 64 23 13 - SCROLL WATER CHILLERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for scroll water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Packaged, water-cooled, electric-motor-driven, scroll water chillers.
  - b. Packaged, air-cooled, electric-motor-driven, scroll water chillers.
  - c. Packaged refrigerant recovery units.

#### C. Definitions

1. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
2. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
3. IPLV: Integrated part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
4. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
5. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

#### D. Performance Requirements

1. Seismic Performance: Scroll water chillers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittal:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
3. Certificates: For certification required in "Quality Assurance" Article.
4. Seismic Qualification Certificates: For water chillers, accessories, and components from manufacturers.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Startup service reports.
6. Operation and maintenance data.
7. Warranty: Sample of special warranty.

## F. Quality Assurance

1. ARI Certification: Certify chiller according to ARI 590 certification program.
2. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
3. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
5. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
6. Comply with NFPA 70.

## G. Delivery, Storage, And Handling

1. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
2. Package water chiller for export shipping.

## H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within five years from date of Final Completion.

## 1.2 PRODUCTS

## A. Packaged Water-Cooled Water Chillers

1. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
2. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
3. Compressors:
  - a. Description: Positive-displacement direct drive with hermetically sealed casing.
  - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
  - c. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
  - d. Capacity Control: On-off compressor cycling, plus hot-gas bypass, **as directed**.
  - e. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
  - f. Vibration Isolation: Mount individual compressors on vibration isolators.
  - g. Sound-reduction package shall consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.
4. Compressor Motors:
  - a. Hermetically sealed and cooled by refrigerant suction gas.
  - b. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
5. Compressor Motor Controllers:
  - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
6. Refrigeration:
  - a. Refrigerant: R-407C **OR** R-410A, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
  - b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - c. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.

- d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
- 7. Evaporator:
  - a. Brazed-plate or shell-and-tube design, as indicated.
  - b. Shell and Tube:
    - 1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
    - 2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 3) Shell Material: Carbon steel.
    - 4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
    - 5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
    - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
  - c. Brazed Plate:
    - 1) Direct-expansion, single-pass, brazed-plate design.
    - 2) Type 316 stainless-steel construction.
    - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
- 8. Condenser:
  - a. Shell and tube or without integral condenser; as indicated.
  - b. Shell and Tube:
    - 1) Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
    - 2) Provides positive subcooling of liquid refrigerant.
    - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 4) Shell Material: Carbon steel.
    - 5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
    - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
    - 7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.
  - c. Provide water chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 23 Section "Air-cooled Refrigerant Condensers".
- 9. Electrical Power:
  - a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
  - b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
  - c. Wiring shall be numbered and color-coded to match wiring diagram.
  - d. Install factory wiring outside of an enclosure in a raceway.
  - e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
  - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
    - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.

- 2) NEMA KS 1, heavy-duty, nonfusible switch.
- 3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- g. Provide each motor with overcurrent protection.
- h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
- i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
- j. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
- k. Control Relays: Auxiliary and adjustable time-delay relays.
- l. Indicate the following for water chiller electrical power supply:
  - 1) Current, phase to phase, for all three phases.
  - 2) Voltage, phase to phase and phase to neutral for all three phases.
  - 3) Three-phase real power (kilowatts).
  - 4) Three-phase reactive power (kilovolt amperes reactive).
  - 5) Power factor.
  - 6) Running log of total power versus time (kilowatt hours).
  - 7) Fault log, with time and date of each.
10. Controls:
  - a. Stand-alone, microprocessor based.
  - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
  - c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
    - 1) Date and time.
    - 2) Operating or alarm status.
    - 3) Operating hours.
    - 4) Outside-air temperature if required for chilled-water reset.
    - 5) Temperature and pressure of operating set points.
    - 6) Entering and leaving temperatures of chilled water.
    - 7) Entering and leaving temperatures of condenser water.
    - 8) Refrigerant pressures in evaporator and condenser.
    - 9) Saturation temperature in evaporator and condenser.
    - 10) No cooling load condition.
    - 11) Elapsed time meter (compressor run status).
    - 12) Pump status.
    - 13) Antirecycling timer status.
    - 14) Percent of maximum motor amperage.
    - 15) Current-limit set point.
    - 16) Number of compressor starts.
  - d. Control Functions:
    - 1) Manual or automatic startup and shutdown time schedule.
    - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
    - 3) Current limit and demand limit.
    - 4) Condenser-water temperature.
    - 5) External water chiller emergency stop.
    - 6) Antirecycling timer.
    - 7) Automatic lead-lag switching.
  - e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
    - 1) Low evaporator pressure or high condenser pressure.
    - 2) Low chilled-water temperature.
    - 3) Refrigerant high pressure.



- 4) High or low oil pressure.
- 5) High oil temperature.
- 6) Loss of chilled-water flow.
- 7) Loss of condenser-water flow.
- 8) Control device failure.
- f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
  - 1) Hardwired Points:
    - a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
    - b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
  - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.
11. Insulation:
  - a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
  - b. Thickness: **3/4 inch (19 mm)**.
  - c. Factory-applied insulation over cold surfaces of water chiller components.
    - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
  - d. Apply protective coating to exposed surfaces of insulation.
12. Accessories:
  - a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
  - b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
  - c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.
- B. Packaged Air-Cooled Water Chillers
  1. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
  2. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.
  3. Cabinet:
    - a. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit.
    - b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
    - c. Casing: Galvanized steel.
    - d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.
    - e. Sound-reduction package consisting of the following:
      - 1) Acoustic enclosure around compressors.
      - 2) Reduced-speed fans with acoustic treatment.
      - 3) Designed to reduce sound level without affecting performance.
    - f. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.
  4. Compressors:

- a. Description: Positive-displacement direct drive with hermetically sealed casing.
- b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
- c. Operating Speed: Nominal 3600 rpm for 60-Hz applications.
- d. Capacity Control: On-off compressor cycling, plus hot-gas bypass, **as directed**.
- e. Oil Lubrication System: Automatic pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
- f. Vibration Isolation: Mount individual compressors on vibration isolators.
5. Compressor Motors:
  - a. Hermetically sealed and cooled by refrigerant suction gas.
  - b. High-torque, two-pole induction type with inherent thermal-overload protection on each phase.
6. Compressor Motor Controllers:
  - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.
7. Refrigeration:
  - a. Refrigerant: R-407c **OR** R-410a, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
  - b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - c. Refrigerant Circuit: Each circuit shall include a thermal-expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
  - d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
8. Evaporator:
  - a. Brazed-plate or shell-and-tube design, as indicated.
  - b. Shell and Tube:
    - 1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
    - 2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 3) Shell Material: Carbon steel.
    - 4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
    - 5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
    - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
  - c. Brazed Plate:
    - 1) Direct-expansion, single-pass, brazed-plate design.
    - 2) Type 316 stainless-steel construction.
    - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
  - d. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to **minus 20 deg F (minus 29 deg C)**.
  - e. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.
9. Air-Cooled Condenser:
  - a. Plate-fin coil with integral subcooling on each circuit, rated at **450 psig (3103 kPa)**.
    - 1) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.

- 2) Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
- 3) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
- b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
- c. Fan Motors: Totally enclosed nonventilating (TENV) or totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
- d. Fan Guards: Steel safety guards with corrosion-resistant coating.
10. Electrical Power:
  - a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
  - b. House in a unit-mounted, NEMA 250, Type 3R, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
  - c. Wiring shall be numbered and color-coded to match wiring diagram.
  - d. Install factory wiring outside of an enclosure in a raceway.
  - e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
  - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
    - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - 2) NEMA KS 1, heavy-duty, nonfusible switch.
    - 3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
  - g. Provide each motor with overcurrent protection.
  - h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
  - i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
  - j. Provide power factor correction capacitors to correct power factor to 0.90 **OR** 0.95, **as directed**, at full load.
  - k. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
    - 1) Power unit-mounted controls where indicated.
    - 2) Power unit-mounted, ground fault interrupt (GFI) duplex receptacle.
  - l. Control Relays: Auxiliary and adjustable time-delay relays.
  - m. Indicate the following for water chiller electrical power supply:
    - 1) Current, phase to phase, for all three phases.
    - 2) Voltage, phase to phase and phase to neutral for all three phases.
    - 3) Three-phase real power (kilowatts).
    - 4) Three-phase reactive power (kilovolt amperes reactive).
    - 5) Power factor.
    - 6) Running log of total power versus time (kilowatt hours).
    - 7) Fault log, with time and date of each.
11. Controls:
  - a. Stand-alone, microprocessor based.
  - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
  - c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
    - 1) Date and time.
    - 2) Operating or alarm status.
    - 3) Operating hours.
    - 4) Outside-air temperature if required for chilled-water reset.
    - 5) Temperature and pressure of operating set points.
    - 6) Entering and leaving temperatures of chilled water.

- 7) Refrigerant pressures in evaporator and condenser.
  - 8) Saturation temperature in evaporator and condenser.
  - 9) No cooling load condition.
  - 10) Elapsed time meter (compressor run status).
  - 11) Pump status.
  - 12) Antirecycling timer status.
  - 13) Percent of maximum motor amperage.
  - 14) Current-limit set point.
  - 15) Number of compressor starts.
  - d. Control Functions:
    - 1) Manual or automatic startup and shutdown time schedule.
    - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
    - 3) Current limit and demand limit.
    - 4) External water chiller emergency stop.
    - 5) Antirecycling timer.
    - 6) Automatic lead-lag switching.
  - e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
    - 1) Low evaporator pressure or high condenser pressure.
    - 2) Low chilled-water temperature.
    - 3) Refrigerant high pressure.
    - 4) High or low oil pressure.
    - 5) High oil temperature.
    - 6) Loss of chilled-water flow.
    - 7) Control device failure.
  - f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
    - 1) Hardwired Points:
      - a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
      - b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
    - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to remotely control and monitor the water chiller from an operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.
12. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
  - b. Thickness: **3/4 inch (19 mm) OR 1-1/2 inches (38 mm), as directed.**
  - c. Factory-applied insulation over cold surfaces of water chiller components.
    - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
  - d. Apply protective coating to exposed surfaces of insulation.
13. Accessories:
- a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
  - b. Individual compressor suction and discharge pressure gages with shutoff valves for each refrigeration circuit.
  - c. Factory-furnished neoprene **OR** spring, **as directed**, isolators for field installation.

C. Packaged Refrigerant Recovery Units

1. Packaged portable unit shall consist of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest water chiller.

D. Source Quality Control

1. Perform functional test of water chillers before shipping.
2. Factory performance test water chillers, **as directed**, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
  - a. Allow the Owner access to place where water chillers are being tested. Notify the Owner 14 days in advance of testing.
3. Factory test and inspect evaporator and water-cooled condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
4. For water chillers located indoors, rate sound power level according to ARI 575 procedure.
5. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.

1.3 EXECUTION

A. Water Chiller Installation

1. Install water chillers on support structure indicated.
2. Equipment Mounting: Install water chiller on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1 inch (25 mm), as directed.**
  - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install water chiller using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1 inch (25 mm), as directed.**
4. Equipment Mounting: Install water chiller on vibration isolation inertia bases. Comply with requirements specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Equipment Mounting: Install water chiller on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Maintain manufacturer's recommended clearances for service and maintenance.
7. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
8. Install separate devices furnished by manufacturer and not factory installed.

**B. Connections**

1. Comply with requirements in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements in Division 23 Section "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to chiller to allow service and maintenance.
4. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
5. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15, **as directed**.
7. Connect each drain connection with a union and drain pipe and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

**C. Startup Service**

1. Perform startup service.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
3. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
  - a. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
  - b. Verify that pumps are installed and functional.
  - c. Verify that thermometers and gages are installed.
  - d. Operate water chiller for run-in period.
  - e. Check bearing lubrication and oil levels.
  - f. Verify that refrigerant pressure relief device for chillers installed indoors is vented outside.
  - g. Verify proper motor rotation.
  - h. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.
  - i. Verify and record performance of chilled-water and condenser-water, **as directed**, flow and low-temperature interlocks.
  - j. Verify and record performance of water chiller protection devices.
  - k. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
4. Prepare a written startup report that records results of tests and inspections.

END OF SECTION 23 64 23 13

## SECTION 23 64 23 16 - RECIPROCATING WATER CHILLERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for reciprocating water chillers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Packaged, water-cooled, electric-motor-driven, reciprocating water chillers.
  - b. Packaged, air-cooled, electric-motor-driven, reciprocating water chillers.
  - c. Packaged refrigerant recovery units.

#### C. Definitions

1. COP: Coefficient of performance. The ratio of the rate of heat removal to the rate of energy input using consistent units for any given set of rating conditions.
2. EER: Energy-efficiency ratio. The ratio of the cooling capacity given in terms of Btu/h to the total power input given in terms of watts at any given set of rating conditions.
3. IPLV: Integrated part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and referenced to ARI standard rating conditions.
4. kW/Ton: The ratio of total power input of the chiller in kilowatts to the net refrigerating capacity in tons at any given set of rating conditions.
5. NPLV: Nonstandard part-load value. A single number part-load efficiency figure of merit calculated per the method defined by ARI 550/590 and intended for operating conditions other than the ARI standard rating conditions.

#### D. Performance Requirements

1. Seismic Performance: Reciprocating water chillers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.
2. Seismic Qualification Certificates: For water chillers, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
3. Source quality-control test reports.
4. Startup service reports.
5. Operation and maintenance data.
6. Warranty: Sample of special warranty.

#### F. Quality Assurance

1. ARI Certification: Certify chiller according to ARI 590 certification program.





2. ARI Rating: Rate water chiller performance according to requirements in ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
3. ASHRAE Compliance: ASHRAE 15 for safety code for mechanical refrigeration.
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
5. ASME Compliance: Fabricate and stamp water chiller heat exchangers to comply with ASME Boiler and Pressure Vessel Code.
6. Comply with NFPA 70.

G. Delivery, Storage, And Handling

1. Ship water chillers from the factory fully charged with refrigerant and filled with oil.
2. Package water chiller for export shipping.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within five years from date of Final Completion.

## 1.2 PRODUCTS

A. Packaged Water-Cooled Water Chillers

1. Description: Factory-assembled and run-tested water chiller complete with compressor(s), compressor motors and motor controllers, evaporator, condenser where indicated, electrical power, controls, and indicated accessories.
2. Fabricate water chiller mounting base with reinforcement strong enough to resist water chiller movement during a seismic event when water chiller is anchored to field support structure.
3. Compressors:
  - a. Description: Positive-displacement direct drive with semihermetically sealed and accessible bolted casings.
  - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
  - c. Operating Speed: 1750 rpm for 60-Hz applications.
  - d. Capacity Control: Combinations of cylinder unloading and on-off compressor cycling of multiple compressors, **as directed**, plus hot-gas bypass, **as directed**. Compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
  - e. Oil Lubrication System: Automatically reversible, positive-displacement pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
  - f. Vibration Isolation: Mount individual compressors on either neoprene or spring isolators.
  - g. Sound-reduction package shall consist of acoustic enclosures around the compressors that are designed to reduce sound level without affecting performance.
4. Compressor Motors:
  - a. Hermetically sealed and cooled by refrigerant suction gas.
  - b. High-torque, four-pole induction type with inherent thermal-overload protection on each phase.
5. Compressor Motor Controllers:
  - a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.  
**OR**  
Part-Wind Start: NEMA ICS 2, Class A, reduced voltage, nonreversing.
6. Refrigeration:
  - a. Refrigerant: R-407C **OR** R-410A, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.

- b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - c. Refrigerant Circuit: Each circuit shall include a thermal **OR** an electronic, **as directed**, expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
  - d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
7. Evaporator:
- a. Brazed-plate or shell-and-tube design, as indicated.
  - b. Shell and Tube:
    - 1) Description: Direct-expansion, shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
    - 2) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 3) Shell Material: Carbon steel.
    - 4) Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
    - 5) Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
    - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
  - c. Brazed Plate:
    - 1) Direct-expansion, single-pass, brazed-plate design.
    - 2) Type 316 stainless-steel construction.
    - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
8. Condenser:
- a. Shell and tube, brazed plate, or without integral condenser; as indicated.
  - b. Shell and Tube:
    - 1) Description: Shell-and-tube design with refrigerant flowing through the shell and fluid flowing through the tubes within the shell.
    - 2) Provides positive subcooling of liquid refrigerant.
    - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 4) Shell Material: Carbon steel.
    - 5) Water Boxes: Removable, of carbon-steel construction, located at each end of the tube bundle with fluid nozzles terminated with mechanical-coupling end connections for connection to field piping.
    - 6) Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
    - 7) Provide each condenser with a pressure relief device, purge cock, and liquid-line shutoff valve.
  - c. Brazed Plate:
    - 1) Single-pass, brazed-plate design provides positive subcooling of liquid refrigerant.
    - 2) Type 316 stainless-steel construction.
    - 3) Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.
    - 4) Fluid Nozzles: Terminate with mechanical-coupling end connections for connection to field piping.
    - 5) Provide each condenser with a liquid-line shutoff valve.

- d. Provide water chiller without an integral condenser and design chiller for field connection to remote condenser. Coordinate requirements with Division 23 Section "Air-cooled Refrigerant Condensers".
- 9. Electrical Power:
  - a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
  - b. House in a unit-mounted, NEMA 250, Type 1, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
  - c. Wiring shall be numbered and color-coded to match wiring diagram.
  - d. Install factory wiring outside of an enclosure in a raceway.
  - e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
  - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
    - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - 2) NEMA KS 1, heavy-duty, nonfusible switch.
    - 3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
  - g. Provide each motor with overcurrent protection.
  - h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
  - i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
  - j. Controls Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
  - k. Control Relays: Auxiliary and adjustable time-delay relays.
  - l. Indicate the following for water chiller electrical power supply:
    - 1) Current, phase to phase, for all three phases.
    - 2) Voltage, phase to phase and phase to neutral for all three phases.
    - 3) Three-phase real power (kilowatts).
    - 4) Three-phase reactive power (kilovolt amperes reactive).
    - 5) Power factor.
    - 6) Running log of total power versus time (kilowatt hours).
    - 7) Fault log, with time and date of each.
- 10. Controls:
  - a. Stand-alone, microprocessor based.
  - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
  - c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
    - 1) Date and time.
    - 2) Operating or alarm status.
    - 3) Operating hours.
    - 4) Outside-air temperature if required for chilled-water reset.
    - 5) Temperature and pressure of operating set points.
    - 6) Entering and leaving temperatures of chilled water.
    - 7) Entering and leaving temperatures of condenser water.
    - 8) Refrigerant pressures in evaporator and condenser.
    - 9) Saturation temperature in evaporator and condenser.
    - 10) No cooling load condition.
    - 11) Elapsed time meter (compressor run status).
    - 12) Pump status.
    - 13) Antirecycling timer status.
    - 14) Percent of maximum motor amperage.
    - 15) Current-limit set point.

- 16) Number of compressor starts.
  - d. Control Functions:
    - 1) Manual or automatic startup and shutdown time schedule.
    - 2) Entering and leaving chilled-water temperatures, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
    - 3) Current limit and demand limit.
    - 4) Condenser-water temperature.
    - 5) External water chiller emergency stop.
    - 6) Antirecycling timer.
    - 7) Automatic lead-lag switching.
  - e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
    - 1) Low evaporator pressure or high condenser pressure.
    - 2) Low chilled-water temperature.
    - 3) Refrigerant high pressure.
    - 4) High or low oil pressure.
    - 5) High oil temperature.
    - 6) Loss of chilled-water flow.
    - 7) Loss of condenser-water flow.
    - 8) Control device failure.
  - f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
    - 1) Hardwired Points:
      - a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
      - b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
    - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to control and monitor the water chiller from a remote operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.
11. Insulation:
- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
  - b. Thickness: **3/4 inch (19 mm)**.
  - c. Factory-applied insulation over cold surfaces of water chiller components.
    - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
  - d. Apply protective coating to exposed surfaces of insulation.
12. Accessories:
- a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
  - b. Individual compressor suction and discharge pressure gages with shutoff valves.
  - c. Factory-furnished spring isolators for field installation.

#### B. Packaged Air-Cooled Water Chillers

1. Description: Factory-assembled and run-tested water chiller complete with base and frame, condenser casing, compressors, compressor motors and motor controllers, evaporator, condenser coils, condenser fans and motors, electrical power, controls, and accessories.
2. Fabricate base, frame, and attachment to water chiller components strong enough to resist movement during a seismic event when water chiller base is anchored to field support structure.
3. Cabinet:

- a. Base: Galvanized-steel base extending the perimeter of water chiller. Secure frame, compressors, and evaporator to base to provide a single-piece unit. Base shall be designed to limit deflection to L/200 and shall be a minimum of **4 inches (100 mm)** high.
  - b. Frame: Rigid galvanized-steel frame secured to base and designed to support cabinet, condenser, control panel, and other chiller components not directly supported from base.
  - c. Casing: Galvanized steel.
  - d. Finish: Coat base, frame, and casing with a corrosion-resistant coating capable of withstanding a 500-hour salt-spray test according to ASTM B 117.
  - e. Sound-reduction package consisting of the following:
    - 1) Acoustic enclosure around compressors.
    - 2) Reduced-speed fans with acoustic treatment.
    - 3) Designed to reduce sound level without affecting performance.
  - f. Security Package: Provide security grilles with fasteners for additional protection of compressors, evaporator, and condenser coils. Grilles shall be coated for corrosion resistance and shall be removable for service access.
4. Compressors:
- a. Description: Positive-displacement direct drive with semihermetically sealed and accessible bolted casings.
  - b. Each compressor provided with suction and discharge service valves, crankcase oil heater, and suction strainer.
  - c. Operating Speed: 1750 rpm for 60-Hz applications.
  - d. Capacity Control: Combinations of cylinder unloading and on-off compressor cycling of multiple compressors, plus hot-gas bypass, **as directed**. Compressor shall be capable of operating at part-load conditions without increased vibration over normal vibration at full-load operation and shall be capable of continuous operation at its lowest step of unloading.
  - e. Oil Lubrication System: Automatically reversible, positive-displacement pump with strainer, sight glass, filling connection, filter with magnetic plug, and initial oil charge.
  - f. Vibration Isolation: Mount individual compressors on spring isolators with an isolation efficiency of 95 percent.
5. Compressor Motors:
- a. Hermetically sealed and cooled by refrigerant suction gas.
  - b. High-torque, four-pole induction type with inherent thermal-overload protection on each phase.
6. Compressor Motor Controllers:
- a. Across the Line: NEMA ICS 2, Class A, full voltage, nonreversing.  
**OR**  
Part-Wind Start: NEMA ICS 2, Class A, reduced voltage, nonreversing.
7. Refrigeration:
- a. Refrigerant: R-407C **OR** R-410A, **as directed**. Classified as Safety Group A1 according to ASHRAE 34.
  - b. Refrigerant Compatibility: Parts exposed to refrigerants shall be fully compatible with refrigerants, and pressure components shall be rated for refrigerant pressures.
  - c. Refrigerant Circuit: Each circuit shall include a thermal **OR** an electronic, **as directed**, expansion valve, refrigerant charging connections, a hot-gas muffler, compressor suction and discharge shutoff valves, a liquid-line shutoff valve, a replaceable-core filter-dryer, a sight glass with moisture indicator, a liquid-line solenoid valve, and an insulated suction line.
  - d. Refrigerant Isolation: Factory install positive shutoff isolation valves in the compressor discharge line and the refrigerant liquid-line to allow the isolation and storage of the refrigerant charge in the chiller condenser.
8. Evaporator:
- a. Description: Direct-expansion shell-and-tube design with fluid flowing through the shell and refrigerant flowing through the tubes within the shell.
  - b. Code Compliance: Tested and stamped according to ASME Boiler and Pressure Vessel Code.

- c. Shell Material: Carbon steel.
  - d. Shell Heads: Removable carbon-steel heads with multipass baffles designed to ensure positive oil return and located at each end of the tube bundle.
  - e. Shell Nozzles: Fluid nozzles located along the side of the shell and terminated with mechanical-coupling end connections for connection to field piping.
  - f. Tube Construction: Individually replaceable copper tubes with enhanced fin design, expanded into tube sheets.
  - g. Heater: Factory-installed and -wired electric heater with integral controls designed to protect the evaporator to **minus 20 deg F (minus 29 deg C)**.
  - h. Remote Mounting: Designed for remote field mounting where indicated. Provide kit for field installation.
9. Air-Cooled Condenser:
- a. Plate-fin coil with integral subcooling circuit, leak tested at **150 psig (1034 kPa)**.
    - 1) Construct coils of copper tubes mechanically bonded to aluminum **OR** aluminum with precoated epoxy-phenolic **OR** copper, **as directed**, fins.
    - 2) Coat coils with a baked epoxy corrosion-resistant coating after fabrication.
    - 3) Hail Protection: Provide condenser coils with louvers, baffles, or hoods to protect against hail damage.
  - b. Fans: Direct-drive propeller type with statically and dynamically balanced fan blades, arranged for vertical air discharge.
  - c. Fan Motors: Totally enclosed air over (TEAO) enclosure, with permanently lubricated bearings, and having built-in overcurrent- and thermal-overload protection.
  - d. Fan Guards: Steel safety guards with corrosion-resistant coating.
10. Electrical Power:
- a. Factory-installed and -wired switches, motor controllers, transformers, and other electrical devices necessary shall provide a single-point field power connection to water chiller.
  - b. House in a unit-mounted, NEMA 250, Type 3R **OR** Type 4, **as directed**, enclosure with hinged access door with lock and key or padlock and key.
  - c. Wiring shall be numbered and color-coded to match wiring diagram.
  - d. Install factory wiring outside of an enclosure in a raceway.
  - e. Field power interface shall be to wire lugs **OR** NEMA KS 1, heavy-duty, nonfused disconnect switch, **as directed**.
  - f. Provide branch power circuit to each motor and to controls with one of the following disconnecting means:
    - 1) NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 60947-4-1.
    - 2) NEMA KS 1, heavy-duty, nonfusible switch.
    - 3) NEMA AB 1, motor-circuit protector (circuit breaker) with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
  - g. Provide each motor with overcurrent protection.
  - h. Overload relay sized according to UL 1995, or an integral component of water chiller control microprocessor.
  - i. Phase-Failure and Undervoltage: Solid-state sensing with adjustable settings.
  - j. Transformer: Unit-mounted transformer with primary and secondary fuses and sized with enough capacity to operate electrical load plus spare capacity.
    - 1) Power unit-mounted controls where indicated.
    - 2) Power unit-mounted, ground-fault interrupt (GFI) duplex receptacle.
  - k. Control Relays: Auxiliary and adjustable time-delay relays.
  - l. Indicate the following for water chiller electrical power supply:
    - 1) Current, phase to phase, for all three phases.
    - 2) Voltage, phase to phase and phase to neutral for all three phases.
    - 3) Three-phase real power (kilowatts).
    - 4) Three-phase reactive power (kilovolt amperes reactive).
    - 5) Power factor.
    - 6) Running log of total power versus time (kilowatt hours).
    - 7) Fault log, with time and date of each.

11. Controls:
- a. Stand-alone, microprocessor based.
  - b. Enclosure: Share enclosure with electrical power devices or provide a separate enclosure of matching construction.
  - c. Operator Interface: Keypad or pressure-sensitive touch screen. Multiple-character, backlit, liquid-crystal display or light-emitting diodes. Display the following:
    - 1) Date and time.
    - 2) Operating or alarm status.
    - 3) Operating hours.
    - 4) Outside-air temperature if required for chilled-water reset.
    - 5) Temperature and pressure of operating set points.
    - 6) Entering and leaving temperatures of chilled water.
    - 7) Refrigerant pressures in evaporator and condenser.
    - 8) Saturation temperature in evaporator and condenser.
    - 9) No cooling load condition.
    - 10) Elapsed time meter (compressor run status).
    - 11) Pump status.
    - 12) Antirecycling timer status.
    - 13) Percent of maximum motor amperage.
    - 14) Current-limit set point.
    - 15) Number of compressor starts.
  - d. Control Functions:
    - 1) Manual or automatic startup and shutdown time schedule.
    - 2) Entering and leaving chilled-water temperature, control set points, and motor load limit. Chilled-water leaving temperature shall be reset based on return-water **OR** outside-air **OR** space, **as directed**, temperature.
    - 3) Current limit and demand limit.
    - 4) External water chiller emergency stop.
    - 5) Antirecycling timer.
    - 6) Automatic lead-lag switching.
  - e. Manual-Reset Safety Controls: The following conditions shall shut down water chiller and require manual reset:
    - 1) Low evaporator pressure or high condenser pressure.
    - 2) Low chilled-water temperature.
    - 3) Refrigerant high pressure.
    - 4) High or low oil pressure.
    - 5) High oil temperature.
    - 6) Loss of chilled-water flow.
    - 7) Control device failure.
  - f. Building Automation System Interface: Factory-installed hardware and software to enable building automation system to monitor, control, and display water chiller status and alarms.
    - 1) Hardwired Points:
      - a) Monitoring: On/off status, common trouble alarm **OR** electrical power demand (kilowatts) **OR** electrical power consumption (kilowatt hours), **as directed**.
      - b) Control: On/off operation, chilled-water discharge temperature set-point adjustment **OR** electrical power demand limit, **as directed**.
    - 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Industry-accepted open-protocol, **as directed**, communication interface with building automation system shall enable building automation system operator to control and monitor the water chiller from a remote operator workstation. Control features and monitoring points displayed locally at water chiller control panel shall be available through building automation system.

12. Insulation:



- a. Material: Closed-cell, flexible elastomeric, thermal insulation complying with ASTM C 534, Type I, for tubular materials and Type II, for sheet materials.
    - b. Thickness: 3/4 inch (19 mm).
    - c. Factory-applied insulation over cold surfaces of water chiller components.
      - 1) Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface. Seal seams and joints.
    - d. Apply protective coating to exposed surfaces of insulation.
  - 13. Accessories:
    - a. Factory-furnished, chilled-water and condenser-water, **as directed**, flow switches for field installation.
    - b. Individual compressor suction and discharge pressure gages with shutoff valves.
    - c. Factory-furnished spring isolators for field installation.
  - C. Packaged Refrigerant Recovery Units
    - 1. Packaged portable unit shall consist of compressor, air-cooled condenser, recovery system, tank pressure gages, filter-dryer, and valving that allows for switching between liquid and vapor recovery mode. Refrigerant recovery unit shall be factory mounted on an ASME-constructed and -stamped refrigerant storage vessel that is sized to hold the full refrigerant charge of the largest water chiller.
  - D. Source Quality Control
    - 1. Perform functional test of water chillers before shipping.
    - 2. Factory performance test water chillers, **as directed**, before shipping, according to ARI 550/590, "Water Chilling Packages Using the Vapor Compression Cycle."
      - a. Allow the Owner access to place where water chillers are being tested. Notify the Owner 14 days in advance of testing.
    - 3. Factory test and inspect evaporator and water-cooled condenser, **as directed**, according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1. Stamp with ASME label.
    - 4. For water chillers located indoors, rate sound power level according to ARI 575 procedure.
    - 5. For water chillers located outdoors, rate sound power level according to ARI 370 procedure.
- 1.3 EXECUTION
- A. Water Chiller Installation
    - 1. Install water chillers on support structure indicated.
    - 2. Equipment Mounting: Install water chiller on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
      - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.
      - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
      - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
    - 3. Equipment Mounting: Install water chiller using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
      - a. Minimum Deflection: 1/4 inch (6 mm) **OR** 1 inch (25 mm), **as directed**.



4. Equipment Mounting: Install water chiller on vibration isolation inertia bases. Comply with requirements specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Equipment Mounting: Install water chiller on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
6. Maintain manufacturer's recommended clearances for service and maintenance.
7. Charge water chiller with refrigerant if not factory charged and fill with oil if not factory installed.
8. Install separate devices furnished by manufacturer and not factory installed.

#### B. Connections

1. Comply with requirements in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements in Division 23 Section "Refrigerant Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to chiller to allow service and maintenance.
4. Evaporator Fluid Connections: Connect to evaporator inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to evaporator outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
5. Condenser Fluid Connections: Connect to condenser inlet with shutoff valve, strainer, **as directed**, flexible connector, **as directed**, thermometer, and plugged tee with pressure gage. Connect to condenser outlet with shutoff valve, balancing valve, flexible connector, **as directed**, flow switch, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Make connections to water chiller with a union **OR** flange **OR** mechanical coupling, **as directed**.
6. Refrigerant Pressure Relief Valve Connections: For water chillers installed indoors, extend vent piping to the outside without valves or restrictions. Comply with ASHRAE 15, **as directed**.
7. Connect each drain connection with a union and drain pipe, and extend pipe, full size of connection, to floor drain. Provide a shutoff valve at each connection if required.

#### C. Startup Service

1. Perform startup service.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
3. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
  - a. Verify that refrigerant charge is sufficient and water chiller has been leak tested.
  - b. Verify that pumps are installed and functional.
  - c. Verify that thermometers and gages are installed.
  - d. Operate water chiller for run-in period.
  - e. Check bearing lubrication and oil levels.
  - f. Verify that refrigerant pressure relief for chillers installed indoors is vented outside.
  - g. Verify proper motor rotation.
  - h. Verify static deflection of vibration isolators, including deflection during water chiller startup and shutdown.

- i. Verify and record performance of chilled-water and condenser-water, **as directed**, flow and low-temperature interlocks.
  - j. Verify and record performance of water chiller protection devices.
  - k. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.
4. Prepare a written startup report that records results of tests and inspections.

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Task	Specification	Specification Description
23 64 26 13	23 61 16 00a	Rotary-Screw Water Chillers

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## SECTION 23 65 13 16 - COOLING TOWERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for cooling towers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Closed-circuit, forced-draft, counterflow cooling towers.
  - b. Closed-circuit, induced-draft, combined-flow cooling towers.
  - c. Closed-circuit, induced-draft, counterflow cooling towers.
  - d. Open-circuit, forced-draft, counterflow cooling towers.
  - e. Open-circuit, induced-draft, counterflow cooling towers.
  - f. Open-circuit, induced-draft, crossflow cooling towers.

#### C. Definitions

1. BMS: Building management system.
2. FRP: Fiber-reinforced polyester.

#### D. Performance Requirements

1. Delegated Design: Design cooling tower support structure and seismic restraints, **as directed**, and wind restraints, **as directed**, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Cooling tower support structure shall withstand the effects of gravity loads and loads and stresses within limits and under conditions indicated according to SEI/ASCE 7.
3. Seismic Performance: Cooling towers shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, pressure drop, fan performance data, rating curves with selected points indicated, furnished specialties, and accessories.
  - a. Maximum flow rate.
  - b. Minimum flow rate.
  - c. Drift loss as percent of design flow rate.
  - d. Volume of water in suspension for purposes of sizing a remote storage tank.
  - e. Sound power levels in eight octave bands for operation with fans off, fans at minimum, and design speed.
  - f. Performance curves for the following:
    - 1) Varying entering-water temperatures from design to minimum.
    - 2) Varying ambient wet-bulb temperatures from design to minimum.
    - 3) Varying water flow rates from design to minimum.
    - 4) Varying fan operation (off, minimum, and design speed).
  - g. Fan airflow, brake horsepower, and drive losses.
  - h. Pump flow rate, head, brake horsepower, and efficiency.



- i. Motor amperage, efficiency, and power factor at 100, 75, 50, and 25 percent of nameplate horsepower.
  - j. Electrical power requirements for each cooling tower component requiring power.
2. Shop Drawings: Complete set of manufacturer's prints of cooling tower assemblies, control panels, sections and elevations, and unit isolation. Include the following:
  - a. Assembled unit dimensions.
  - b. Weight and load distribution.
  - c. Required clearances for maintenance and operation.
  - d. Sizes and locations of piping and wiring connections.
  - e. Wiring Diagrams: For power, signal, and control wiring.
3. Delegated-Design Submittal: For cooling tower support structure indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Detail fabrication and assembly of support structure.
  - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
  - c. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and wind restraints, **as directed**, and for designing vibration isolation bases.
  - d. Coordination Drawings: Floor plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
    - e. Structural supports.
    - f. Piping roughing-in requirements.
    - g. Wiring roughing-in requirements, including spaces reserved for electrical equipment.
    - h. Access requirements, including working clearances for mechanical controls and electrical equipment, and tube pull and service clearances.
4. Certificates: For certification required in "Quality Assurance" Article.
5. Seismic Qualification Certificates: For cooling towers, accessories, and components, from manufacturers.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Source quality-control reports.
7. Field quality-control reports.
8. Startup service reports.
9. Operation and Maintenance Data: For each cooling tower to include in emergency, operation, and maintenance manuals.
10. Warranty: Sample of special warranty.

F. Quality Assurance

1. Testing Agency Qualifications: Certified by CTI **OR** An NRTL, **as directed**.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
4. ASME Compliance: Fabricate and label heat-exchanger coils to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
5. CTI Certification: Cooling tower thermal performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."
6. FMG approval and listing in the latest edition of FMG's "Approval Guide."

- G. Coordination
1. Coordinate sizes and locations of concrete bases with actual equipment provided.
  2. Coordinate sizes, locations, and anchoring attachments of structural-steel support structures.
  3. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.
- H. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace the following components of cooling towers that fail in materials or workmanship within specified warranty period:
    - a. Fan assembly including fan, drive, and motor.
    - b. All components of cooling tower.
    - c. Warranty Period: Five years from date of Final Completion.

## 1.2 PRODUCTS

- A. Closed-Circuit, Forced-Draft, Counterflow Cooling Towers
1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
  2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
  3. Casing and Frame:
    - a. Casing **OR** Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
    - d. Joints and Seams: Sealed watertight.
    - e. Welded Connections: Continuous and watertight.
  4. Collection Basin: Configure tower for installation with a field-constructed collection basin.  
**OR**  
Collection Basin:
    - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
    - c. Overflow and drain connections.
    - d. Makeup water connection.
    - e. Basin Sweeper Distribution Piping and Nozzles:
      - 1) Pipe Material: PVC.
      - 2) Nozzle Material: Plastic.
      - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
  5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.  
**OR**  
Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
    - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
    - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR**



- control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
- c. Electrode Probes: Stainless steel.
  - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
  - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
  - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
- a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
  - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
  - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
  - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
  - e. Control-circuit transformer with primary and secondary side fuses.
  - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
  - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
- OR**
- Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
7. Water Distribution Piping: Main header and lateral branch piping designed for even distribution over fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
- a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
  - b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
  - c. Piping Supports: Corrosion-resistant hangers and supports designed to resist movement during operation and shipment.
8. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.
9. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.
- a. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
  - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
  - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
  - d. Service Factor: 1.0 **OR** 1.15, **as directed**.
10. Heat-Exchanger Coils:
- a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.
  - b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover

- plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.
- OR**
- ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
- c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.
11. Removable, **as directed**, Drift Eliminator:
- a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
- b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
- c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
12. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**, -steel wire mesh.
13. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.
- a. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
- b. Fan Wheel and Housing Materials: Galvanized steel.
- c. Fan Shaft: Steel, coated to resist corrosion.
- d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
- e. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**. Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
- f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
14. Belt Drive:
- a. Belt-Drive Service Factor: 1.5 based on motor nameplate horsepower.
- b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
- c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.
- OR**
- Belt: One-piece, multigrooved, solid-back belt.
- d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
- e. Belt-Drive Guard: Comply with OSHA regulations.
- f. Two-Motor, Single-Fan Drive:
- 1) Two single-speed motors per fan, one sized for full speed and load, and the other sized for 67 percent of full-load speed.
- 2) Belt Drives: Each motor shall have belt drive complying with requirements for belt drives and configured for operation when other motor fails.
- 3) Motor controller and wiring same as two-speed, two-winding motor.
15. Fan Motor:
- a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
- b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
- c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
- d. Service Factor: 1.15.
- e. Insulation: Class F **OR** Class H, **as directed**.



- f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
- g. Severe-duty rating with the following features:
  - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
  - 2) Double-shielded, vacuum-degassed bearings lubricated with premium moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**.
  - 3) Internal heater automatically energized when motor is de-energized.
- h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
- 16. Discharge Hoods:
  - a. Hood Configuration: Tapered **OR** Straight, **as directed**; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed insulation, **as directed**, and access doors.
  - b. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.
    - 1) Provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.
- 17. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
- 18. Vibration Switch: For each fan drive.
  - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Vibration Detection: Sensor with a field-adjustable acceleration sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
  - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS and, **as directed**, hardwired connection to fan motor electrical circuit.
  - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS and, **as directed**, shut down the fan.
- 19. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
 Control Package: Factory installed and wired, and functionally tested at factory before shipment.
  - a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
  - b. Control-circuit transformer with primary and secondary side fuses.
  - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
  - d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
  - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
  - f. Collection basin, electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
  - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
  - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
  - i. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.
  - j. Power and controls to open discharge hood dampers when pump is energized and close dampers when pump is de-energized.
  - k. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.

- 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
  - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
  - l. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
  - m. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
  - n. Audible alarm and silence switch.
  - o. Visual indication of elapsed run time, graduated in hours for each motor.
  - p. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
    - 1) Operational status of each motor.
    - 2) Position of dampers.
    - 3) Cooling tower leaving-fluid temperature.
    - 4) Fan vibration alarm.
    - 5) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
20. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both, **as directed**, cooling tower end walls. Doors shall be operable from both sides of the door, **as directed**.
  - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
  - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
  - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard at platforms and around top of cooling tower. Comply with 29 CFR 1910.23.
  - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
    - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
- B. Closed-Circuit, Induced-Draft, Combined-Flow Cooling Towers
1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
  2. Cooling tower designed to resist wind load of **30 lbf/sq. ft. (1.44 kPa) OR as directed**.
  3. Casing and Frame:
    - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
    - d. Joints and Seams: Sealed watertight.
    - e. Welded Connections: Continuous and watertight.
  4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
 

**OR**

Collection Basin:

    - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
    - c. Overflow and drain connections.





- d. Makeup water connection.
- e. Basin Sweeper Distribution Piping and Nozzles:
  - 1) Pipe Material: PVC, **as directed**.
  - 2) Nozzle Material: Plastic, **as directed**.
  - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
- 5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
 

**OR**

Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:

  - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
  - c. Electrode Probes: Stainless steel.
  - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
  - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
  - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.

**OR**

Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:

  - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
  - c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
  - d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
  - e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
- 6. Electric Basin Heater:
  - a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
  - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
  - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
  - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
  - e. Control-circuit transformer with primary and secondary side fuses.
  - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
  - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

**OR**

Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

**OR**

Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

**OR**

Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.



7. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.
  - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G210 (Z600)** coating **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
  - b. Location: Over each bank of fill with easily replaceable plastic, **as directed**, spray nozzles mounted in bottom of basin.
  - c. Joints and Seams: Sealed watertight.
  - d. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
  - e. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable corrosion-resistant **OR** stainless-steel, **as directed**, hardware.
  - f. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity water distribution basin.
8. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
  - a. Pipe Material: PVC **OR** Galvanized steel, **as directed**.
  - b. Spray Nozzle Material: Plastic **OR** Polypropylene, **as directed**.
  - c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
9. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.
10. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.
  - a. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
  - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
  - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
  - d. Service Factor: 1.0 **OR** 1.15, **as directed**.
11. Fill:
  - a. Materials: PVC, **as directed**, with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
  - b. Minimum Thickness: **15 mils (0.4 mm)** **OR** **20 mils (0.5 mm)**, **as directed**, before forming.
  - c. Fabrication: Fill-type sheets fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
  - d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through **120 deg F (49 deg C)**.
12. Heat-Exchanger Coils:
  - a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.
  - b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.  
**OR**  
ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.

- c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.
- 13. Drift Eliminator:
  - a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 according to ASTM E 84.
  - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
  - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
  - d. Fill Drift Eliminators: Integral to **OR** Separate and removable from, **as directed**, fill.
  - e. Heat-Exchanger Coil Drift Eliminators: Located on discharge side and removable.
- 14. Air-Intake Louvers:
  - a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
  - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
  - c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
  - d. Location: Integral to **OR** Separate from, **as directed**, fill.
- 15. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**, -steel wire mesh.
- 16. Axial Fan: Balanced at the factory after assembly.
  - a. Blade Material: Aluminum **OR** FRP, **as directed**.
  - b. Hub Material: Aluminum **OR** FRP, **as directed**.
  - c. Blade Pitch: Field adjustable.
  - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
  - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**. Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
  - f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
- 17. Belt Drive:
  - a. Service Factor: 1.5 based on motor nameplate horsepower.
  - b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
  - c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.  
**OR**  
Belt: One-piece, multigrooved, solid-back belt.
  - d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
  - e. Belt-Drive Guard: Comply with OSHA regulations.
  - f. Two-Motor, Single-Fan Drive:
    - 1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
    - 2) Each motor with belt drive and configured for operation when other motor fails.
    - 3) Controls and wiring same as two-speed, two-winding motor.
- 18. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
  - a. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
  - b. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
  - c. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
  - d. Operation: Able to operate both forward and in reverse.

- e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
- f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
- g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.
- 19. Fan Motor:
  - a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
  - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
  - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
  - d. Service Factor: 1.15.
  - e. Insulation: Class F **OR** Class H, **as directed**.
  - f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
  - g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
  - h. Severe-duty rating with the following features:
    - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
    - 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F** (minus 29 and plus 149 deg C).
    - 3) Internal heater automatically energized when motor is de-energized.
  - i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
- 20. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
  - a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
  - b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
- 21. Vibration Switch: For each fan drive.
  - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
  - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
  - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
- 22. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
  - a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
- 23. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Control Package: Factory installed and wired, and functionally tested at factory before shipment.
  - a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
  - b. Control-circuit transformer with primary and secondary side fuses.
  - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.

- d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
  - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
  - f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
  - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
  - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
  - i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
  - j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
    - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
    - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
  - k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
  - l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
  - m. Audible alarm and silence switch.
  - n. Visual indication of elapsed run time, graduated in hours for each motor.
  - o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
    - 1) Operational status of each motor.
    - 2) Position of dampers.
    - 3) Cooling tower leaving-fluid temperature.
    - 4) Fan vibration alarm.
    - 5) Oil-level alarm.
    - 6) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
24. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
  - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
  - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
  - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
  - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
    - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
    - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

### C. Closed-Circuit, Induced-Draft, Counterflow Cooling Towers

1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
2. Cooling tower designed to resist wind load of **30 lbf/sq. ft. (1.44 kPa) OR as directed.**
3. Casing and Frame:
  - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G210 (Z600)** coating **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Stainless steel, **as directed.**
  - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G210 (Z600)** coating **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed.**
  - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
  - d. Joints and Seams: Sealed watertight.
  - e. Welded Connections: Continuous and watertight.
4. Collection Basin: Configure tower for installation with a field-constructed collection basin.  
**OR**  
Collection Basin:
  - a. Material: Galvanized steel, ASTM A 653/A 653M, **G210 (Z600)** coating **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Stainless steel, **as directed.**
  - b. Overflow and drain connections.
  - c. Makeup water connection.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.  
**OR**  
Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
  - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed.**
  - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed.**
  - c. Electrode Probes: Stainless steel.
  - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed.**
  - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
  - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
  - a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
  - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
  - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed.**
  - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
  - e. Control-circuit transformer with primary and secondary side fuses.
  - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
  - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.

**OR**  
Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.  
**OR**  
Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.  
**OR**





- Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
7. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
    - a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
    - b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
    - c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
  8. Recirculating Piping: PVC, **as directed**, with connections for separately provided, remote spray pump, **as directed**.
  9. Spray Pump: Close-coupled, end-suction, single-stage, bronze-fitted centrifugal pump; with suction strainer and flow balancing valve, and mechanical seal suitable for outdoor service.
  10. General Requirements for Spray Pump Motor: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
    - a. Motor Enclosure: Totally enclosed **OR** Totally enclosed nonventilated (TENV) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
    - b. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
    - c. Service Factor: 1.0 **OR** 1.15, **as directed**.
  11. Heat-Exchanger Coils:
    - a. Tube and Tube Sheet Materials: Copper tube with stainless-steel sheet **OR** Stainless-steel tube and sheet **OR** Prime-coated steel tube and sheet with outer surface of tube and sheet hot-dip galvanized after fabrication, **as directed**.
    - b. Heat-Exchanger Arrangement: Serpentine tubes **OR** Serpentine tubes with removable cover plate on inlet and outlet headers **OR** Straight tubes with removable header cover plate on both ends of heat exchanger for straight-through access to each tube, **as directed**; and sloped for complete drainage of fluid by gravity.  
**OR**  
ASME Compliance: Designed, manufactured, and tested according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1 and bearing ASME "U" stamp; and sloped for complete drainage of fluid by gravity.
    - c. Field Piping Connections: Vent, supply, and return suitable for mating to ASME B16.5, Class 150 flange, **as directed**.
  12. Removable, **as directed**, Drift Eliminator:
    - a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
    - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
    - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
  13. Air-Intake Louvers:
    - a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
    - b. UV Treatment: Treat louvers with inhibitors to protect against damage caused by UV radiation.
    - c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out during all modes of operation including operation with fans off.
  14. Axial Fan: Balanced at the factory after assembly.
    - a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
    - b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
    - c. Blade Pitch: Field adjustable.
    - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
    - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus**

- 300 deg F (minus 29 and plus 149 deg C).** Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
- f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
15. Belt Drive:
- a. Service Factor: 1.5 based on motor nameplate horsepower.
- b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
- c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.  
**OR**  
Belt: One-piece, multigrooved, solid-back belt.
- d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
- e. Belt-Drive Guard: Comply with OSHA regulations.
- f. Two-Motor, Single-Fan Drive:
- 1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
- 2) Each motor with belt drive and configured for operation when other motor fails.
- 3) Controls and wiring same as two-speed, two-winding motor.
16. Fan Motor:
- a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
- b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
- c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
- d. Service Factor: 1.15.
- e. Insulation: Class F **OR** Class H, **as directed**.
- f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
- g. Severe-duty rating with the following features:
- 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
- 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**.
- 3) Internal heater automatically energized when motor is de-energized.
- h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
17. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
- a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
- b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
18. Vibration Switch: For each fan drive.
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
- b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
- c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
- d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
19. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Control Package: Factory installed and wired, and functionally tested at factory before shipment.





- a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
  - b. Control-circuit transformer with primary and secondary side fuses.
  - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
  - d. Microprocessor-based controller for automatic control of fan and spray pump, **as directed**, based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
  - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
  - f. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
  - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
  - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
  - i. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker **OR** for each cooling tower cell, **as directed**.
    - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
    - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
  - j. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
  - k. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
  - l. Audible alarm and silence switch.
  - m. Visual indication of elapsed run time, graduated in hours for each motor.
  - n. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
    - 1) Operational status of each motor.
    - 2) Cooling tower leaving-fluid temperature.
    - 3) Fan vibration alarm.
    - 4) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
20. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
  - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
  - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
  - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
  - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
    - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
    - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

#### D. Open-Circuit, Forced-Draft, Counterflow Cooling Towers

1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
2. Cooling tower designed to resist wind load of **30 lbf/sq. ft. (1.44 kPa) OR as directed.**
3. Casing and Frame:
  - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G210 (Z600)** coating **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed.**
  - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G210 (Z600)** coating **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed.**
  - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
  - d. Joints and Seams: Sealed watertight.
  - e. Welded Connections: Continuous and watertight.
4. Collection Basin: Configure tower for installation with a field-constructed collection basin.  
**OR**  
Collection Basin:
  - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G210 (Z600)** coating **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed.**
  - b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
  - c. Overflow and drain connections.
  - d. Makeup water connection.
  - e. Basin Sweeper Distribution Piping and Nozzles:
    - 1) Pipe Material: PVC, **as directed.**
    - 2) Nozzle Material: Plastic, **as directed.**
    - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
6. Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
  - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed.**
  - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed.**
  - c. Electrode Probes: Stainless steel.
  - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed.**
  - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
  - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
7. Electric Basin Heater:
  - a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
  - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
  - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed.**
  - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
  - e. Control-circuit transformer with primary and secondary side fuses.
  - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.



- h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
  - i. Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
8. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
    - a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
    - b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
    - c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
  9. Fill:
    - a. Materials: PVC, **as directed**, with maximum flame-spread index of 5 according to ASTM E 84.
    - b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
    - c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
    - d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
  10. Removable, **as directed**, Drift Eliminator:
    - a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
    - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
    - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
  11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**, steel wire mesh.
  12. Centrifugal Fan: Double-width, double-inlet, forward-curved blades, and statically and dynamically balanced at the factory after assembly.
    - a. Number of Fans: Each cooling tower cell shall have a single fan or multiple fans connected to a common shaft.
    - b. Fan Wheel and Housing Materials: Galvanized steel.
    - c. Fan Shaft: Steel, coated to resist corrosion.
    - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
    - e. Fan Shaft Bearings: Self-aligning, grease-lubricated ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
    - f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
  13. Axial Fan: Balanced at the factory after assembly.
    - a. Blade Material: FRP, **as directed**.
    - b. Hub Material: Aluminum **OR** FRP, **as directed**.
    - c. Blade Pitch: Field adjustable.
    - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
    - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between minus 20 and plus 300 deg F (minus 29 and plus 149 deg C). Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
    - f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.

14. Belt Drive:
- a. Service Factor: 1.5 based on motor nameplate horsepower.
  - b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
  - c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.  
**OR**  
Belt: One-piece, multigrooved, solid-back belt.
  - d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
  - e. Belt-Drive Guard: Comply with OSHA regulations.
  - f. Two-Motor, Single-Fan Drive:
    - 1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
    - 2) Each motor with belt drive and configured for operation when other motor fails.
    - 3) Controls and wiring same as two-speed, two-winding motor.
15. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.
16. Fan Motor:
- a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
  - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
  - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
  - d. Service Factor: 1.15.
  - e. Insulation: Class F **OR** Class H, **as directed**.
  - f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
  - g. Severe-duty rating with the following features:
    - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
    - 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and 300 deg F (minus 29 and 149 deg C)**.
    - 3) Internal heater automatically energized when motor is de-energized.
  - h. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
17. Discharge Hoods:
- a. Hood Configuration: Tapered **OR** Straight, **as directed**; totally surrounding drift eliminators and constructed of same material as casing; and having factory-installed insulation, **as directed**, and access doors.
  - b. Discharge Dampers: Positive-closure, automatic, isolation dampers with electric actuators.
    - 1) Provide field power and controls to open dampers when pump is energized and close dampers when pump is de-energized.
18. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
19. Vibration Switch: For each fan drive.
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
  - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
  - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
20. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".

**OR**

Control Package: Factory installed and wired, and functionally tested at factory before shipment.

- a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
  - b. Control-circuit transformer with primary and secondary side fuses.
  - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
  - d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
  - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
  - f. Factory-installed and -wired, collection basin electric/electronic level controller.
  - g. Collection basin electric/electronic level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" Paragraph.
  - h. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
  - i. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
  - j. Controls and wiring for "two-motor, single-fan drives" shall be same as two-speed, two-winding motor.
  - k. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
    - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
    - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
  - l. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
  - m. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
  - n. Audible alarm and silence switch.
  - o. Visual indication of elapsed run time, graduated in hours for each motor.
  - p. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
    - 1) Operational status of each motor.
    - 2) Position of dampers.
    - 3) Cooling tower leaving-fluid temperature.
    - 4) Fan vibration alarm.
    - 5) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
21. Personnel Access Components:
- a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
  - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
  - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
  - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
  - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.

- 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
- 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.

E. Open-Circuit, Induced-Draft, Counterflow Cooling Towers

1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
  2. Cooling tower designed to resist wind load of 30 lbf/sq. ft. (1.44 kPa) **OR as directed**.
  3. Casing and Frame:
    - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
    - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Stainless steel, **as directed**.
    - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
    - d. Joints and Seams: Sealed watertight.
    - e. Welded Connections: Continuous and watertight.
  4. Collection Basin: Configure tower for installation with a field-constructed collection basin.  
**OR**  
Collection Basin:
    - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, G210 (Z600) coating **OR** Galvanized steel, ASTM A 653/A 653M, G235 (Z700) coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - b. Strainer: Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
    - c. Overflow and drain connections.
    - d. Makeup water connection.
    - e. Outlet Connection: ASME B16.5, Class 150 flange.
    - f. Removable equalization flume plate between adjacent cells of multiple-cell towers.
    - g. Equalizer connection for field-installed equalizer piping.
    - h. Basin Sweeper Distribution Piping and Nozzles:
      - 1) Pipe Material: PVC, **as directed**.
      - 2) Nozzle Material: Plastic, **as directed**.
      - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
  5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.  
**OR**  
Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
    - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
    - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
    - c. Electrode Probes: Stainless steel.
    - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
    - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
    - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
- OR**  
Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:



- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
  - c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
  - d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
  - e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
- a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
  - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
  - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
  - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
  - e. Control-circuit transformer with primary and secondary side fuses.
  - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
  - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
- OR**
- Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.
7. Pressurized Water Distribution Piping: Main header and lateral branch piping designed for even distribution over heat-exchanger coil or fill throughout the flow range without the need for balancing valves and for connecting individual, removable, nonclogging spray nozzles.
- a. Pipe Material: Fiberglass **OR** PVC **OR** Galvanized steel, **as directed**.
  - b. Spray Nozzle Material: Plastic **OR** Polypropylene **OR** PVC, **as directed**.
  - c. Piping Supports: Corrosion-resistant hangers and supports to resist movement during operation and shipment.
8. Fill:
- a. Materials: CPVC **OR** PVC, **as directed**, resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
  - b. Minimum Thickness: 15 mils (0.4 mm) **OR** 20 mils (0.5 mm), **as directed**, before forming.
  - c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
  - d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through 120 deg F (49 deg C).
9. Removable, **as directed**, Drift Eliminator:
- a. Material: FRP **OR** PVC, **as directed**; resistant to rot, decay, and biological attack; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
  - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
  - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
10. Air-Intake Louvers:
- a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
  - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.



- c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
- 11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**, -steel wire mesh.
- 12. Axial Fan: Balanced at the factory after assembly.
  - a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
  - b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
  - c. Blade Pitch: Field adjustable.
  - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens, complying with OSHA regulations.
  - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**. Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
  - f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
- 13. Belt Drive:
  - a. Service Factor: 1.5 based on motor nameplate horsepower.
  - b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
  - c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.  
**OR**  
Belt: One-piece, multigrooved, solid-back belt.
  - d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
  - e. Belt-Drive Guard: Comply with OSHA regulations.
- 14. Direct Drive: Fan hub directly connected, and properly secured, to motor shaft.
- 15. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
  - a. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
  - b. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
  - c. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
  - d. Operation: Able to operate both forward and in reverse.
  - e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
  - f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
  - g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.
- 16. Fan Motor:
  - a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 15 Section "Common Motor Requirements for HVAC Equipment" and not indicated below.
  - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
  - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
  - d. Service Factor: 1.15.
  - e. Insulation: Class F **OR** Class H, **as directed**.

- f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
- g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
- h. Severe-duty rating with the following features:
  - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
  - 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C)**.
  - 3) Internal heater automatically energized when motor is de-energized.
- i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
- 17. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
  - a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
  - b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
- 18. Vibration Switch: For each fan drive.
  - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
  - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
  - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
- 19. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
  - a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
- 20. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Control Package: Factory installed and wired, and functionally tested at factory before shipment.
  - a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
  - b. Control-circuit transformer with primary and secondary side fuses.
  - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
  - d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
  - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
  - f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
  - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
  - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
  - i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
  - j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
    - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.

- 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
- k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
- l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
- m. Audible alarm and silence switch.
- n. Visual indication of elapsed run time, graduated in hours for each motor.
- o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
  - 1) Operational status of each motor.
  - 2) Position of dampers.
  - 3) Cooling tower leaving-fluid temperature.
  - 4) Fan vibration alarm.
  - 5) Oil-level alarm.
  - 6) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
21. Personnel Access Components:
  - a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
  - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
  - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
  - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
  - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
    - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
    - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.
- F. Open-Circuit, Induced-Draft, Crossflow Cooling Towers
  1. Fabricate cooling tower mounting base with reinforcement strong enough to resist cooling tower movement during a seismic event when cooling tower is anchored to field support structure.
  2. Cooling tower designed to resist wind load of **30 lbf/sq. ft. (1.44 kPa)**, **as directed**.
  3. Casing and Frame:
    - a. Casing and Frame, **as directed**, Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - b. Frame Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - c. Fasteners: Galvanized **OR** Stainless, **as directed**, steel.
    - d. Joints and Seams: Sealed watertight.
    - e. Welded Connections: Continuous and watertight.
  4. Collection Basin: Configure tower for installation with a field-constructed collection basin.
 

**OR**

Collection Basin:

    - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
    - b. Removable stainless-steel, **as directed**, strainer with openings smaller than nozzle orifices.
    - c. Overflow and drain connections.

- d. Makeup water connection.
  - e. Outlet Connection: ASME B16.5, Class 150 flange.
  - f. Removable equalization flume plate between adjacent cells of multiple-cell towers.
  - g. Equalizer connection for field-installed equalizer piping.
  - h. Basin Sweeper Distribution Piping and Nozzles:
    - 1) Pipe Material: PVC, **as directed**.
    - 2) Nozzle Material: Plastic, **as directed**.
    - 3) Configure piping and nozzles to minimize sediment from collecting in the collection basin.
5. Mechanically Operated, Collection Basin Water-Level Control: Manufacturer's standard adjustable, mechanical float assembly and valve.
- OR**
- Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve:
- a. Enclosures: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Sensor: Solid-state controls with multiple electrode probes and relays factory wired to a terminal strip to provide control of water makeup valve **OR** control of water makeup valve and low-level alarm **OR** control of water makeup valve and low- and high-level alarms **OR** control of water makeup valve, low- and high-level alarms, and output for shutoff of pump on low level, **as directed**.
  - c. Electrode Probes: Stainless steel.
  - d. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
  - e. Solenoid Valve: Slow closing with stainless-steel body, **as directed**, controlled and powered through level controller in response to water-level set point.
  - f. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
- OR**
- Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve:
- a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Controller: Ultrasonic level sensor/transmitter and relays factory wired to a terminal strip to control water makeup valve and signal a level alarm. Controller shall provide continuous level indication through a 4- to 20-mA signal for connection to BMS, **as directed**.
  - c. Water Stilling Chamber: Corrosion-resistant material **OR** FRP **OR** Galvanized steel **OR** PVC pipe **OR** Stainless steel, **as directed**.
  - d. Solenoid Valve: Slow closing with stainless-steel body, **as directed**; controlled and powered through level controller in response to water-level set point.
  - e. Electrical Connection Requirements: 120 V, single phase, 60 Hz.
6. Electric Basin Heater:
- a. Stainless-Steel Electric Immersion Heaters: Installed in a threaded coupling on the side of the collection basin.
  - b. Heater Control Panel: Mounted on the side of each cooling tower cell.
  - c. Enclosure: NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.
  - d. Magnetic contactors controlled by a temperature sensor/controller to maintain collection basin water-temperature set point. Water-level probe shall monitor cooling tower water level and de-energize the heater when the water reaches low-level set point.
  - e. Control-circuit transformer with primary and secondary side fuses.
  - f. Terminal blocks with numbered and color-coded wiring to match wiring diagram.
  - g. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, and heater branch circuiting complying with NFPA 70.
  - h. Factory Wiring Method: Metal raceway for factory-installed wiring outside of enclosures, except make connections to each electric basin heater with liquidtight conduit.
- OR**
- Hot-Water-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.
- OR**
- Steam-Coil Basin Heater: Manufacturer's standard offering to provide capacity indicated.

**OR**

Steam-Injector Basin Heater: Manufacturer's standard offering to provide capacity indicated.

7. Gravity Water Distribution Basin: Nonpressurized design with head of water level in basin adequate to overcome spray nozzle losses and designed to evenly distribute water over fill throughout the flow range indicated.
  - a. Material: FRP with UV inhibitors **OR** Galvanized steel, ASTM A 653/A 653M, **G235 (Z700)** coating **OR** Polymer-coated galvanized steel **OR** Stainless steel, **as directed**.
  - b. Location: Over each bank of fill with easily replaceable plastic, **as directed**, spray nozzles mounted in bottom of basin.
  - c. Inlet Connection: ASME B16.5, Class 150 flange.
  - d. Joints and Seams: Sealed watertight.
  - e. Partitioning Dams: Same material as basin to distribute water over the fill to minimize icing while operating throughout the flow range indicated.
  - f. Removable Panels: Same material as basin to completely cover top of basin. Secure panels to basin with removable corrosion-resistant **OR** stainless-steel, **as directed**, hardware.
  - g. Valves: Manufacturer's standard valve installed at each inlet connection and arranged to balance or shut off flow to each gravity distribution basin.
  - h. Single-Inlet, Field Pipe Connection: Galvanized-steel **OR** PVC, **as directed**, pipe arranged to provide balancing of flow within cooling tower cell without the need for additional balancing valves. Pipe each cooling tower cell internally to a single, field connection suitable for mating to ASME B16.5, Class 150 flange and located on the bottom **OR** side, **as directed**, unless otherwise indicated.
8. Fill:
  - a. Materials: PVC, with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
  - b. Minimum Thickness: **15 mils (0.4 mm) OR 20 mils (0.5 mm)**, **as directed**, before forming.
  - c. Fabrication: Fill-type sheets, fabricated, formed, and bonded together after forming into removable assemblies that are factory installed by manufacturer.
  - d. Fill Material Operating Temperature: Suitable for entering-water temperatures up through **120 deg F (49 deg C)**.
9. Drift Eliminator:
  - a. Material: FRP **OR** PVC, **as directed**; with maximum flame-spread index of 5 **OR** 25, **as directed**, according to ASTM E 84.
  - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
  - c. Configuration: Multipass, designed and tested to reduce water carryover to achieve performance indicated.
  - d. Location: Integral to **OR** Separate and removable from, **as directed**, fill.
10. Air-Intake Louvers:
  - a. Material: FRP **OR** PVC **OR** Matching casing, **as directed**.
  - b. UV Treatment: Inhibitors to protect against damage caused by UV radiation.
  - c. Louver Blades: Arranged to uniformly direct air into cooling tower, to minimize air resistance, and to prevent water from splashing out of tower during all modes of operation including operation with fans off.
  - d. Location: Integral to **OR** Separate from, **as directed**, fill.
11. Removable, **as directed**, Air-Intake Screens: Galvanized **OR** Polymer-coated, galvanized **OR** Stainless, **as directed**, -steel wire mesh.
12. Axial Fan: Balanced at the factory after assembly.
  - a. Blade Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
  - b. Hub Material: Aluminum **OR** FRP **OR** Galvanized steel, **as directed**.
  - c. Blade Pitch: Field adjustable.
  - d. Protective Enclosure: Removable, galvanized-steel, wire-mesh screens complying with OSHA regulations.
  - e. Fan Shaft Bearings: Self-aligning ball or roller bearings with moisture-proof seals and premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus**



- 300 deg F (minus 29 and plus 149 deg C).** Bearings designed for an L-10 life of 40,000 **OR** 50,000, **as directed**, hours.
- f. Bearings Grease Fittings: Extended lubrication lines to an easily accessible location.
13. Belt Drive:
- a. Service Factor: 1.5 based on motor nameplate horsepower.
  - b. Sheaves: Fan and motor shafts shall have taper-lock sheaves fabricated from corrosion-resistant materials.
  - c. Belt: Multiple V-belt design with a matched set of cogged, **as directed**, belts.  
**OR**  
Belt: One-piece, multigrooved, solid-back belt.
  - d. Belt Material: Oil resistant, nonstatic conducting, and constructed of neoprene polyester cord.
  - e. Belt-Drive Guard: Comply with OSHA regulations.
  - f. Two-Motor, Single-Fan Drive:
    - 1) Two single-speed motors per fan, one sized for full speed and load and the other sized for 67 percent of full-load speed.
    - 2) Each motor with belt drive and configured for operation when other motor fails.
    - 3) Controls and wiring same as two-speed, two-winding motor.
14. Gear Drive: Right angle, reduced speed, and designed for cooling tower applications according to CTI STD 111. Motor and gear drive shall be aligned before shipment.
- a. Gear Drive and Coupling Service Factor: 2.0 based on motor nameplate horsepower.
  - b. Housing: Cast iron, with epoxy or polyurethane finish, beveled high-strength steel gears continuously bathed in oil, and with lubrication to other internal parts at all operating speeds.
  - c. Mounting: Directly mounted to fan hub and connected to motor so motor shaft is in horizontal position.
  - d. Operation: Able to operate both forward and in reverse.
  - e. Drive-to-Motor Connection: Close coupled to motor using a flexible coupling **OR** Connected to motor located outside of cooling tower casing by a full-floating drive shaft, **as directed**.
  - f. Drive Shaft Material: Corrosion resistant **OR** Stainless steel, **as directed**, and fitted with flexible couplings on both ends. Provide exposed shaft and couplings with guards according to OSHA regulations.
  - g. Extend oil fill, drain, and vent to outside of cooling tower casing using galvanized-steel piping. Provide installation with oil-level sight glass.
15. Fan Motor:
- a. General Requirements for Fan Motors: Comply with NEMA designation and temperature-rating requirements specified in Division 23 Section "Common Motor Requirements For Hvac Equipment" and not indicated below.
  - b. Motor Enclosure: Totally enclosed **OR** Totally enclosed air over (TEAO) **OR** Totally enclosed fan cooled (TEFC), **as directed**, with epoxy or polyurethane finish, **as directed**.
  - c. Energy Efficiency: Comply with ASHRAE/IESNA 90.1 **OR** NEMA Premium Efficient, **as directed**.
  - d. Service Factor: 1.15.
  - e. Insulation: Class F **OR** Class H, **as directed**.
  - f. Variable-Speed Motors: Inverter-duty rated per NEMA MG-1, Section IV, "Performance Standard Applying to All Machines," Part 31, "Definite-Purpose, Inverter-Fed, Polyphase Motors."
  - g. Motor Location: Mounted outside of cooling tower casing and cooling tower discharge airstream.
  - h. Severe-duty rating with the following features:
    - 1) Rotor and stator protected with corrosion-inhibiting epoxy resin.
    - 2) Double-shielded, vacuum-degassed bearings lubricated with premium, moisture-resistant grease suitable for temperatures between **minus 20 and plus 300 deg F (minus 29 and plus 149 deg C).**

- 3) Internal heater automatically energized when motor is de-energized.
- i. Motor Base: Adjustable, or other suitable provision for adjusting belt tension.
16. Fan Discharge Stack: Material shall match casing, manufacturer's standard **OR** velocity recovery, **as directed**, design.
  - a. Stack Extension: Fabricated to extend above fan deck unless otherwise indicated.
  - b. Stack Termination: Wire-mesh, galvanized-steel screens; complying with OSHA regulations.
17. Vibration Switch: For each fan drive.
  - a. Enclosure: NEMA 250, Type 4 **OR** Type 4X, **as directed**.
  - b. Vibration Detection: Sensor with a field-adjustable, acceleration-sensitivity set point in a range of 0 to 1 g and frequency range of 0 to 3000 cycles per minute. Cooling tower manufacturer shall recommend switch set point for proper operation and protection.
  - c. Provide switch with manual-reset button, **as directed**, for field connection to a BMS, **as directed**, and hardwired connection to fan motor electrical circuit.
  - d. Switch shall, on sensing excessive vibration, signal an alarm through the BMS, **as directed**, and shut down the fan.
18. Gear-Drive, Oil-Level Switch: Low-oil-level warning switch for connection to a BMS, **as directed**.
  - a. Switch shall, on reaching a low-oil-level set point recommended by cooling tower manufacturer, signal an alarm through the BMS, **as directed**.
19. Capacity-Control Dampers: Galvanized-steel **OR** Stainless-steel, **as directed**, dampers, with linkages, electric operator, controller, limit switches, transformer, and weatherproof enclosure.
20. Controls: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".  
**OR**  
Control Package: Factory installed and wired, and functionally tested at factory before shipment.
  - a. NEMA 250, Type 3R **OR** Type 4 **OR** Type 4X, **as directed**, enclosure with removable internally mount backplate.
  - b. Control-circuit transformer with primary and secondary side fuses.
  - c. Terminal blocks with numbered and color-coded wiring to match wiring diagram. Spare wiring terminal block for connection to external controls or equipment.
  - d. Microprocessor-based controller for automatic control of fan based on cooling tower leaving-water temperature with control features to improve operating efficiency based on outdoor ambient wet-bulb temperature by using adaptive logic.
  - e. Fan motor sequencer for multiple-cell and two-speed applications with automatic lead stage rotation.
  - f. Collection basin level controller complying with requirements in "Electric/Electronic, Collection Basin Water-Level Controller with Solenoid Valve" **OR** "Ultrasonic Collection Basin Water-Level Controller with Solenoid Valve", **as directed**, Paragraph.
  - g. Electric basin heaters with temperature control and low-water-level safety switch for each cell, complying with requirements in "Electric Basin Heater" Paragraph.
  - h. Vibration switch for each fan, complying with requirements in "Vibration Switch" Paragraph.
  - i. Oil-level switch for each fan with a gear drive, complying with requirement in "Gear-Drive, Oil-Level Switch" Paragraph.
  - j. Single-point, field-power connection to a fused disconnect switch **OR** nonfused disconnect switch **OR** circuit breaker, **as directed**, for each cooling tower cell, **as directed**.
    - 1) Branch power circuit to each motor and electric basin heater and to controls with a disconnect switch or circuit breaker, **as directed**.
    - 2) NEMA-rated motor controller, hand-off-auto switch, and overcurrent protection for each motor. Provide variable frequency controller with manual bypass and line reactors for each variable-speed motor indicated.
  - k. Factory-installed wiring outside of enclosures shall be in metal raceway, except make connections to each motor and electric basin heater with liquidtight conduit.
  - l. Visual indication of status and alarm with momentary test push button, **as directed**, for each motor.
  - m. Audible alarm and silence switch.
  - n. Visual indication of elapsed run time, graduated in hours for each motor.



- o. Cooling tower shall have hardware to enable BMS to remotely monitor and display the following:
  - 1) Operational status of each motor.
  - 2) Position of dampers.
  - 3) Cooling tower leaving-fluid temperature.
  - 4) Fan vibration alarm.
  - 5) Oil-level alarm.
  - 6) Collection basin high **OR** low **OR** high- and low, **as directed**, -water-level alarms.
- 21. Personnel Access Components:
  - a. Doors: Large enough for personnel to access cooling tower internal components from both cooling tower end walls. Doors shall be operable from both sides of the door.
  - b. External Ladders with Safety Cages: Aluminum, galvanized- or stainless-steel, fixed ladders with ladder extensions to access external platforms and top of cooling tower from adjacent grade without the need for portable ladders. Comply with 29 CFR 1910.27.
  - c. External Platforms with Handrails: Aluminum, FRP, or galvanized-steel bar grating at cooling tower access doors when cooling towers are elevated and not accessible from grade.
  - d. Handrail: Aluminum, galvanized steel, or stainless steel complete with kneerail and toeboard, around top of cooling tower. Comply with 29 CFR 1910.23.
  - e. Internal Platforms: Aluminum, FRP, or galvanized-steel bar grating.
    - 1) Spanning the collection basin from one end of cooling tower to the other and positioned to form a path between the access doors. Platform shall be elevated so that all parts are above the high water level of the collection basin.
    - 2) Elevated internal platforms with handrails accessible from fixed vertical ladders to access the fan drive assembly when out of reach from collection basin platform.
- G. Source Quality Control
  - 1. Verification of Performance: Test and certify cooling tower performance according to CTI STD 201, "Certification Standard for Commercial Water-Cooling Towers Thermal Performance."
  - 2. Factory pressure test heat exchangers after fabrication and prove to be free of leaks.

### 1.3 EXECUTION

- A. Examination
  - 1. Before cooling tower installation, examine roughing-in for tower support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting tower performance, maintenance, and operation.
    - a. Cooling tower locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.
  - 2. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Installation
  - 1. Install cooling towers on support structure indicated.
  - 2. Equipment Mounting: Install cooling tower on concrete bases using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
    - a. Minimum Deflection: **1/2 inch (13 mm) OR 1 inch (25 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed.**
    - b. Provide galvanized **OR** stainless, **as directed**, -steel plate to equally distribute weight over elastomeric pad.

- c. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - d. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - e. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  3. Equipment Mounting: Install cooling tower using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
    - a. Minimum Deflection: **1/2 inch (13 mm) OR 1 inch (25 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed.**
    - b. Provide galvanized **OR** stainless, **as directed**, -steel plate to equally distribute weight over elastomeric pad.
  4. Equipment Mounting: Install cooling tower on concrete bases. Comply with requirements in Division 03 Section "Cast-in-place Concrete".
    - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
    - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
    - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  5. Install anchor bolts to elevations required for proper attachment to supported equipment.
  6. Maintain manufacturer's recommended clearances for service and maintenance.
  7. Loose Components: Install electrical components, devices, and accessories that are not factory mounted.
- C. Connections
1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to cooling towers to allow service and maintenance.
  3. Install flexible pipe connectors at pipe connections of cooling towers mounted on vibration isolators.
  4. Provide drain piping with valve at cooling tower drain connections and at low points in piping.
  5. Connect cooling tower overflows and drains, and piping drains to sanitary sewage system.
  6. Domestic Water Piping: Comply with applicable requirements in Division 22 Section "Domestic Water Piping". Connect to water-level control with shutoff valve and union, flange, or mechanical coupling at each connection.
  7. Supply and Return Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Connect to entering cooling tower connections with shutoff valve, balancing valve, thermometer, plugged tee with pressure gage, flow meter, **as directed**, and drain connection with valve. Connect to leaving cooling tower connection with shutoff valve. Make connections to cooling tower with a union **OR** flange **OR** mechanical coupling, **as directed**.
  8. Equalizer Piping: Piping requirements to match supply and return piping. Connect an equalizer pipe, full size of cooling tower connection, between tower cells. Connect to cooling tower with shutoff valve.
  9. Hot-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Connect to supply and return basin heater with shutoff valve, strainer, control valve, and union or flange on supply connection and union or flange and balancing valve on return connection. Provide supply and return piping with pressure gage and thermometer.
  10. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam And Condensate Heating Piping". Connect steam supply to basin heater with shutoff valve, strainer, control valve, and union or flange and condensate piping with union or flange, shutoff valve, strainer, and an appropriate steam trap.

D. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections: Comply with ASME PTC 23, "ASME Performance Test Codes - Code on Atmospheric Water Cooling Equipment **OR** CTI ATC 105, "Acceptance Test Code for Water Cooling Towers", **as directed**.
3. Cooling towers will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

E. Startup Service

1. Perform startup service.
2. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.
3. Obtain performance data from manufacturer.
  - a. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
    - 1) Clean entire unit including basins.
    - 2) Verify that accessories are properly installed.
    - 3) Verify clearances for airflow and for cooling tower servicing.
    - 4) Check for vibration isolation and structural support.
    - 5) Lubricate bearings.
    - 6) Verify fan rotation for correct direction and for vibration or binding and correct problems.
    - 7) Adjust belts to proper alignment and tension.
    - 8) Verify proper oil level in gear-drive housing. Fill with oil to proper level.
    - 9) Operate variable-speed fans through entire operating range and check for harmonic vibration imbalance. Set motor controller to skip speeds resulting in abnormal vibration.
    - 10) Check vibration switch setting. Verify operation.
    - 11) Verify water level in tower basin. Fill to proper startup level. Check makeup water-level control and valve.
    - 12) Verify operation of basin heater and control.
    - 13) Verify that cooling tower air discharge is not recirculating air into tower or HVAC air intakes. Recommend corrective action.
    - 14) Replace defective and malfunctioning units.
4. Start cooling tower and associated water pumps. Follow manufacturer's written starting procedures.
5. Prepare a written startup report that records the results of tests and inspections.

F. Adjusting

1. Set and balance water flow to each tower inlet.
2. Adjust water-level control for proper operating level.

G. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain cooling towers.

END OF SECTION 23 65 13 16



Task	Specification	Specification Description
23 65 14 13	23 65 13 16	Cooling Towers
23 65 14 14	23 65 13 16	Cooling Towers
23 65 14 16	23 65 13 16	Cooling Towers
23 65 43 00	01 22 16 00	No Specification Required
23 65 43 00	23 65 13 16	Cooling Towers
23 71 13 23	21 05 23 00	Piped Utilities Basic Materials And Methods

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## SECTION 23 72 13 00 - AIR-TO-AIR ENERGY RECOVERY UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for air-to-air energy recovery equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Heat wheels.
  - b. Heat-pipe heat exchangers.
  - c. Fixed-plate sensible heat exchangers.
  - d. Fixed-plate total heat exchangers.
  - e. Packaged energy recovery units.

#### C. Performance Requirements

1. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Air-to-air energy recovery equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For air-to-air energy recovery equipment. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For air-to-air energy recovery equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Detail fabrication and assembly of air-to-air energy recovery equipment.
  - b. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
  - c. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from Installers of the items involved:
  - a. Suspended ceiling components.



- b. Structural members to which equipment or suspension systems will be attached.
- 6. Seismic Qualification Certificates: For air-to-air energy recovery equipment, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 7. Field quality-control reports.
- 8. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

#### E. Quality Assurance

- 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2. ARI Compliance:
  - a. Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Performance Rating of Air-to-Air Heat Exchangers for Energy Recovery Ventilation Equipment."
  - b. Capacity ratings for air coils shall comply with ARI 410, "Forced-Circulation Air- Cooling and Air-Heating Coils."
- 3. ASHRAE Compliance:
  - a. Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
  - b. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."
- 4. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.
- 5. UL Compliance:
  - a. Packaged heat recovery ventilators shall comply with requirements in UL 1812, "Ducted Heat Recovery Ventilators"; or UL 1815, "Nonducted Heat Recovery Ventilators."
  - b. Electric coils shall comply with requirements in UL 1995, "Heating and Cooling Equipment."

#### F. Coordination

- 1. Coordinate layout and installation of air-to-air energy recovery equipment and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- 2. Coordinate sizes and locations of concrete bases with actual equipment provided.
- 3. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

#### G. Warranty

- 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of air-to-air energy recovery equipment that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Packaged Energy Recovery Units: Two years.
  - b. Warranty Period for Fixed-Plate Total Heat Exchangers: 10 years.

### 1.2 PRODUCTS

#### A. Heat Wheels

- 1. Casing:
  - a. Steel with standard factory-painted finish.



- b. Integral purge section limiting carryover of exhaust air to between **0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg** (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.
  - c. Casing seals on periphery of rotor and on duct divider and purge section.
  - d. Support vertical rotors on grease-lubricated ball bearings having extended grease fittings or permanently lubricated bearings. Support horizontal rotors on tapered roller bearing.
2. Rotor: Aluminum segmented wheel strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating, **as directed**.
  - a. Maximum Solid Size for Media to Pass: 500 **OR** 800 **OR** 1200, **as directed**, micrometer.
3. Rotor: Glass-fiber **OR** Polymer, **as directed**, segmented wheel strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating.
  - a. Maximum Solid Size for Media to Pass: 800 **OR** 1200, **as directed**, micrometer.
4. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller, **as directed**, and self-adjusting multilink belt around outside of rotor.
  - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
5. Controls:
  - a. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
  - b. Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.  
**OR**  
 Variable frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.  
**OR**  
 Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing and, **as directed**, air differential temperature above set point. Rotor speed shall increase to maximum when exhaust-air temperature is less than outdoor-air temperature.
  - c. Pilot-Light Indicator: Display rotor rotation and speed.
  - d. Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
6. Disposable Panel Filters:
  - a. Comply with NFPA 90A.
  - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - c. Factory-fabricated, viscous-coated, flat-panel type.
  - d. Thickness: **1 inch (25 mm) OR 2 inches (50 mm)**, **as directed**.
  - e. Minimum Arrestance: 80, according to ASHRAE 52.1.
  - f. Minimum Merv: 5, according to ASHRAE 52.2.
  - g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
  - h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
7. Extended-Surface, Disposable Panel Filters:
  - a. Comply with NFPA 90A.
  - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - c. Factory-fabricated, dry, extended-surface type.
  - d. Thickness: **1 inch (25 mm) OR 2 inches (50 mm) OR 4 inches (100 mm)**, **as directed**.
  - e. Minimum Arrestance: 90, according to ASHRAE 52.1.
  - f. Minimum Merv: 7, according to ASHRAE 52.2.

- g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
- h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, **3/4-inch (20-mm)** particleboard with gaskets, **as directed**.
- i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
- 8. Extended-Surface, Nonsupported-Media Filters:
  - a. Comply with NFPA 90A.
  - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - c. Factory-fabricated, dry, extended-surface, self-supporting type.
  - d. Minimum Arrestance: 95, according to ASHRAE 52.1.
  - e. Minimum Merv: 13, according to ASHRAE 52.2.
  - f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed**.
  - g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
  - h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
- B. Heat-Pipe Heat Exchangers
  - 1. Casing: Galvanized-steel flanged casing, with airtight partition between airstreams.
  - 2. Refrigerant: ASHRAE 15, Group 1..
  - 3. Tubes: **5/8-inch- (16-mm-)** **OR** **1-inch- (25-mm-)**, **as directed**, diameter, aluminum **OR** copper, **as directed**.
  - 4. Fins: Aluminum **OR** Integral aluminum **OR** Copper, **as directed**.
    - a. Fin Spacing: **0.125 inch (3.18 mm)** **OR** **0.091 inch (2.31 mm)** **OR** **0.071 inch (1.80 mm)** **OR** **0.067 inch (1.70 mm)** **OR** **0.056 inch (1.42 mm)** **OR** **0.0075 inch (0.19 mm)**, **as directed**.
    - b. Fin and Tube Joint: Mechanical bond **OR** Silver brazed, **as directed**.
  - 5. Coating: Thermoplastic vinyl **OR** Epoxy **OR** Synthetic resin **OR** Phenolic **OR** Polytetrafluoroethylene **OR** Vinyl ester, **as directed**; apply to supply and exhaust.
  - 6. Control: Integral plenum containing heat-pipe coil and gasketed, face-and-bypass, opposed-blade dampers with rods extended outside casing for damper operator and linkage.  
**OR**  
Control: Pivot center of bottom of heat-pipe coil on shaft and bearings to tilt coil. Include tilt controls with electronic controller, electric actuator and linkage, thermostats, sensors, and polyester fabric with PVC-coated flexible connector for automatic supply temperature regulation, summer/winter changeover, and frost protection.
- C. Fixed-Plate Sensible Heat Exchangers
  - 1. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  - 2. Casing: Aluminum **OR** Galvanized steel **OR** Enameled steel, with galvanized-steel liner **OR** Enameled steel, **as directed**, with duct collars.
  - 3. Casing Insulation: **1/2-inch- (13-mm-)** thick, foil-faced glass fiber **OR** **1-inch- (25-mm-)** thick, foil-faced glass fiber **OR** **1 inch (25 mm)** thick, ASTM C 1071 with coated surface **OR** **1 inch (25 mm)** thick, fiber free, **as directed**.
  - 4. Drain Pan: Same material as casing, with drain connections on exhaust and supply side **OR** Molded ABS covering bottom of case, with drain connections on exhaust and supply side, **as directed**.
    - a. Comply with requirements in ASHRAE 62.1.
  - 5. Plates: Evenly spaced and sealed and arranged for counter airflow.
    - a. Plate Material: Embossed aluminum **OR** Stainless steel **OR** Polypropylene copolymer (high-density plastic), **as directed**.
    - b. Plate Coating: Epoxy **OR** Air-dried phenolic, **as directed**.

6. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
  7. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock, with detergent injection, **as directed**.
  8. Disposable Panel Filters:
    - a. Comply with NFPA 90A.
    - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
    - c. Factory-fabricated, viscous-coated, flat-panel type.
    - d. Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed**.
    - e. Minimum Arrestance: 80, according to ASHRAE 52.1.
    - f. Minimum Merv: 5, according to ASHRAE 52.2.
    - g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
    - h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
  9. Extended-Surface, Disposable Panel Filters:
    - a. Comply with NFPA 90A.
    - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
    - c. Factory-fabricated, dry, extended-surface type.
    - d. Thickness: **1 inch (25 mm) OR 2 inches (50 mm) OR 4 inches (100 mm), as directed**.
    - e. Minimum Arrestance: 90, according to ASHRAE 52.1.
    - f. Minimum Merv: 7, according to ASHRAE 52.2.
    - g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
    - h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, **3/4-inch (20-mm) particleboard with gaskets, as directed**.
    - i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
  10. Extended-Surface, Nonsupported-Media Filters:
    - a. Comply with NFPA 90A.
    - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
    - c. Factory-fabricated, dry, extended-surface, self-supporting type.
    - d. Minimum Arrestance: 95, according to ASHRAE 52.1.
    - e. Minimum Merv: 13, according to ASHRAE 52.2.
    - f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed**.
    - g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
    - h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
- D. Fixed-Plate Total Heat Exchangers
1. Casing: Galvanized steel.
  2. Plates: Evenly spaced and sealed and arranged for counter airflow.
    - a. Plate Material: Chemically treated paper with selective hygroscopicity and moisture permeability, and gas barrier properties.
  3. Bypass Plenum: Within casing, with gasketed face-and-bypass dampers having operating rods extended outside casing.
  4. Disposable Panel Filters:
    - a. Comply with NFPA 90A.
    - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.

- c. Factory-fabricated, viscous-coated, flat-panel type.
- d. Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed.**
- e. Minimum Arrestance: 80, according to ASHRAE 52.1.
- f. Minimum Merv: 5, according to ASHRAE 52.2.
- g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed.**
- h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
- 5. Extended-Surface, Disposable Panel Filters:
  - a. Comply with NFPA 90A.
  - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - c. Factory-fabricated, dry, extended-surface type.
  - d. Thickness: **1 inch (25 mm) OR 2 inches (50 mm) OR 4 inches (100 mm), as directed.**
  - e. Minimum Arrestance: 90, according to ASHRAE 52.1.
  - f. Minimum Merv: 7, according to ASHRAE 52.2.
  - g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
  - h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, **3/4-inch (20-mm)** particleboard with gaskets, **as directed.**
  - i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.

#### E. Packaged Energy Recovery Units

- 1. Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- 2. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed and calked weathertight, **as directed**, hinged access doors **OR** removable panels, **as directed**, with neoprene gaskets for inspection and access to internal parts, minimum **1-inch- (25-mm-) OR 2-inch- (50-mm-), as directed**, thick thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
  - a. Inlet: Weatherproof hood **OR** louver, **as directed**, with damper for exhaust and supply.
    - 1) Exhaust: Gravity backdraft damper **OR** Spring-return, two-position, motor-operated damper, **as directed.**
    - 2) Supply: Gravity backdraft damper **OR** Spring-return, two-position, motor-operated damper, **as directed.**
  - b. Roof Curb: Refer to Division 07 Section "Roof Accessories" for roof curbs and equipment supports.
- 3. Heat Recovery Device: Heat wheel **OR** Heat-pipe heat exchanger **OR** Fixed-plate heat exchanger, **as directed.**
- 4. Supply and Exhaust Fans: Forward-curved, centrifugal **OR** Propeller **OR** Backward-inclined, SWSI centrifugal **OR** Backward-inclined, plenum centrifugal, **as directed**, fan with spring isolators **OR** restrained, spring isolators **OR** spring hangers **OR** spring hangers with vertical-limit stops, **as directed**, and insulated, **as directed**, flexible duct connections.
  - a. Motor and Drive: Direct driven **OR** Belt driven with adjustable sheaves, motor mounted on adjustable base **OR** Drive type indicated on Drawings, **as directed.**
  - b. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - c. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
  - e. Spring isolators on each fan having **1-inch (25-mm)** static deflection.
- 5. Disposable Panel Filters:
  - a. Comply with NFPA 90A.

- b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - c. Factory-fabricated, viscous-coated, flat-panel type.
  - d. Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed.**
  - e. Minimum Arrestance: 80, according to ASHRAE 52.1.
  - f. Minimum Merv: 5, according to ASHRAE 52.2.
  - g. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed.**
  - h. Frame: Galvanized steel with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
- 6. Extended-Surface, Disposable Panel Filters:
  - a. Comply with NFPA 90A.
  - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - c. Factory-fabricated, dry, extended-surface type.
  - d. Thickness: **1 inch (25 mm) OR 2 inches (50 mm) OR 4 inches (100 mm), as directed.**
  - e. Minimum Arrestance: 90, according to ASHRAE 52.1.
  - f. Minimum Merv: 7, according to ASHRAE 52.2.
  - g. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
  - h. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, **3/4-inch (20-mm) particleboard with gaskets, as directed.**
  - i. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks.
- 7. Extended-Surface, Nonsupported-Media Filters:
  - a. Comply with NFPA 90A.
  - b. Filter Holding Frames: Arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lift out from access plenum.
  - c. Factory-fabricated, dry, extended-surface, self-supporting type.
  - d. Minimum Arrestance: 95, according to ASHRAE 52.1.
  - e. Minimum Merv: 13, according to ASHRAE 52.2.
  - f. Media: Fibrous material constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions and antimicrobial agent, **as directed.**
  - g. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed.**
  - h. Mounting Frames: Welded, galvanized steel with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed.**
- 8. Cooling Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed.**
  - a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
  - b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed.**
  - c. Tubes: Copper.
  - d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed.**
  - e. Fins: Aluminum **OR** Copper, **as directed.**
  - f. Fin and Tube Joint: Mechanical bond.
  - g. Leak Test: Coils shall be leak tested with air under water.
  - h. Refrigerant Coils:
    - 1) Capacity Reduction: Circuit coils for face **OR** row **OR** interleaved, **as directed**, control.
    - 2) Suction and Distributor: Seamless copper tube with brazed joints.
  - i. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- 9. Cooling-Coil Condensate Drain Pans:



- a. Fabricated from galvanized steel **OR** stainless-steel, **as directed**, sheet and sloped in multiple planes to collect and drain condensate from cooling coils, coil piping connections, coil headers, and return bends.
- b. Complying with requirements in ASHRAE 62.1.
- c. Drain Connections: At low point of pan with minimum **<Insert size>** threaded nipple.
- d. Units with stacked coils shall have an intermediate drain pan to collect and drain condensate from top coil.
- 10. Hot-Water Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed**.
  - a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
  - b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed**.
  - c. Tubes: Copper.
  - d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed**.
  - e. Fins: Aluminum **OR** Copper, **as directed**.
  - f. Fin and Tube Joint: Mechanical bond.
  - g. Leak Test: Coils shall be leak tested with air under water.
  - h. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- 11. Nonfreeze Type, **as directed**, Steam Coils: Rated according to ARI 410 and ASHRAE 33, and bearing the ARI label, **as directed**.
  - a. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service and maintenance of coil(s).
  - b. Casing: Manufacturer's standard material **OR** Aluminum **OR** Galvanized steel **OR** Stainless steel, **as directed**.
  - c. Tubes: Copper.
  - d. Tube Headers: Manufacturer's standard material **OR** Copper **OR** Carbon steel **OR** Red brass, **as directed**.
  - e. Fins: Aluminum **OR** Copper, **as directed**.
  - f. Fin and Tube Joint: Mechanical bond.
  - g. Leak Test: Coils shall be leak tested with air under water.
  - h. Coating: Phenolic epoxy corrosion-protection coating after assembly.
- 12. Electrical Coils, Controls, and Accessories: Comply with UL 1995.
  - a. Casing Assembly: Slip-in **OR** Flanged, **as directed**, type with galvanized-steel frame.
  - b. Access: Fabricate coil section to allow removal and replacement of coil and to allow in-place access for service.
  - c. Sheathed Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.  
**OR**  
Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
  - d. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
  - e. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
  - f. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection.
    - 1) Magnetic **OR** Mercury, **as directed**, contactor.
    - 2) Solid-state, stepless pulse controller.
    - 3) Toggle switches, one per step.
    - 4) Step controller.
    - 5) Time-delay relay.

- 6) Pilot lights, one per step.
- 7) Airflow proving switch.
13. Indirect-Fired Gas Furnaces:
  - a. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
    - 1) AGA Approval: Furnace shall bear label of AGA.
  - b. Burners: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
    - 1) Ignition: Electronically controlled electric spark with flame sensor.
    - 2) High-Altitude Model **OR** Kit, **as directed**: For Project at elevations more than **2000 feet (610 m)** above sea level.
  - c. Heat-Exchanger Drain Pan: Stainless steel.
  - d. Venting: Gravity vented.  
**OR**  
Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
  - e. Gas Control Valve: Single stage **OR** Two stage **OR** Electronic modulating, **as directed**.
  - f. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff. Control devices and control sequence shall comply with requirements of FMG **OR** IRI, **as directed**.
  - g. Access: Fabricate section to allow removal and replacement of furnace and to allow in-place access for service.
14. Piping and Wiring: Fabricate units with space within housing for piping and electrical conduits. Wire motors and controls so only external connections are required during installation.
  - a. Indoor Enclosure: NEMA 250, Type 12 enclosure contains relays, starters, and terminal strip.
  - b. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
  - c. Include fused **OR** nonfused, **as directed**, disconnect switches.
  - d. Variable-speed controller to vary fan capacity from 100 to approximately 50 percent.
15. Accessories:
  - a. Roof Curb: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**, with gasketing, and factory-installed wood nailer; complying with NRCA standards; minimum height of **14 inches (350 mm) OR 24 inches (600 mm)**, **as directed**.
  - b. Intake weather hood with **2-inch- (50-mm-)** thick filters.
  - c. Louvered intake weather hood with **2-inch- (50-mm-)** thick filters in V-bank configuration.
  - d. Exhaust weather hood with birdscreen.
  - e. Low-Leakage, Isolation Dampers: Double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals, in opposed-blade **OR** parallel-blade, **as directed**, arrangement with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, with operating rods connected with a common linkage, and electric damper operator factory wired. Leakage rate shall not exceed **5 cfm/sq. ft. (0.22 L/s per sq. m)** at **1-inch wg (250 Pa)** and **9 cfm/sq. ft. (0.4 L/s per sq. m)** at **4-inch wg (1.0 MPa)**.  
**OR**  
Isolation Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame with operating rods connected with a common linkage, and electric damper operator factory wired. Blades shall have gaskets and edge seals, and shall be mechanically fastened to operating rod.
  - f. Duct flanges.
  - g. Rubber-in-shear isolators for ceiling-mounted units.
  - h. Hinged access doors with quarter-turn latches.
  - i. Drain pans for condensate removal complying with ASHRAE 62.1, **as directed**.





- j. Automatic, in-place, spray-wash system.
- k. Weatherproofing for tilt-control system.

F. Controls

1. Time Clock: Solid-state, programmable, microprocessor-based unit for wall mounting **OR** mounting in outdoor NEMA 250, Type 3R enclosure, **as directed**, with up to eight on/off cycles per day and battery backup protection of program settings against power failure to energize unit.
2. Motion (Occupancy) Sensor: Passive infrared sensor for wall **OR** ceiling, **as directed**, mounting with adjustable time-off delay of up to 30 minutes to energize unit.
3. Carbon Monoxide Sensor: Adjustable control from 600 to 2000 ppm for wall **OR** duct, **as directed**, mounting with digital display and computer/building management system interface to energize unit.
4. Humidistat: Adjustable, wall-mounted instrument to energize unit when space relative humidity exceeds 50 percent.
5. Chilled-Water-Cooling-Coils Controls:
  - a. For chilled-water cooling coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
  - b. For chilled-water cooling coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
6. Refrigerant-Cooling-Coils Controls:
  - a. For refrigerant cooling coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to control remote condensing unit to maintain temperature.
  - b. For refrigerant cooling coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, controls remote condensing unit to maintain temperature.
  - c. Cooling Capacity Control: On/off **OR** Multiple steps, **as directed**.
7. Hot-Water- and Steam-Coils Controls:
  - a. For hot-water or steam coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
  - b. For hot-water or steam coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to modulate factory-mounted **OR** furnished, **as directed**, coil-control valve to maintain temperature.
8. Electric-Coils Controls:
  - a. For electric coils with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel to control electric coil to maintain temperature.
  - b. For electric coils with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to control electric coil to maintain temperature.
  - c. Coil Controls: On/off **OR** Multiple steps **OR** Modulating SCR, **as directed**.
9. Indirect-Fired-Gas-Furnaces Controls:
  - a. For indirect-fired gas furnaces with discharge-air temperature control: Factory-mounted sensor in unit discharge **OR** Remote-mounted sensor for field installation in supply-air duct,

**as directed**, with sensor adjustment located in control panel to control gas furnace burner to maintain temperature.

- b. For indirect-fired gas furnaces with remote temperature control: Wall-mounted, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, to control gas furnace burner to maintain temperature.
- c. Burner Controls: On/off **OR** Multiple steps **OR** Modulating, **as directed**.

### 1.3 EXECUTION

#### A. Examination

- 1. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- 2. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.
- 3. Examine roughing-in for electrical services to verify actual locations of connections before installation.
- 4. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Installation

- 1. Install heat wheels so supply and exhaust airstreams flow in opposite directions and rotation is away from exhaust side to purge section to supply side.
  - a. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to wheel surfaces, drive motor, and seals.
  - b. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
  - c. Access doors and panels are specified in Division 23 Section "Air Duct Accessories".
- 2. Install heat-pipe heat exchangers so supply and exhaust airstreams flow in opposite directions. Install flexible connectors on ducts to enable tilt control; make connections airtight and with slack to compensate for full tilt.
  - a. Install heat exchanger with clearance space for heat-pipe coil removal.
  - b. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to both sides of heat-pipe coil. Access doors and panels are specified in Division 23 Section "Air Duct Accessories".
  - c. Install tilt-control components, including electronic controller, electric actuator and linkage, thermostats, and sensors.
- 3. Install fixed-plate heat exchangers so supply and exhaust airstreams flow in opposite directions.
  - a. Install duct access doors in both supply and exhaust ducts, both upstream and downstream, for access to heat exchanger. Access doors and panels are specified in Division 23 Section "Air Duct Accessories".
- 4. Install gas-fired furnaces according to NFPA 54, "National Fuel Gas Code."
- 5. Install floor-mounted units on **4-inch- (100-mm-)** high concrete base designed to withstand, without damage to equipment, seismic force required by code, **as directed**.
- 6. Equipment Mounting (for equipment supported on a concrete base on grade without vibration isolation devices): Install air-to-air energy recovery equipment on concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
- 7. Roof Curb: Install on roof structure or concrete base, level and secure, according to The NRCA "Roofing and Waterproofing Manual - Volume 4: Construction Details - Low-Slope Roofing,"

Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install air-to-air energy recovery equipment on curbs and coordinate roof penetrations and flashing with roof construction specified in Division 07 Section "Roof Accessories". Secure air-to-air energy recovery equipment to upper curb rail, and secure curb base to roof framing or concrete base with anchor bolts.

8. Unit Support: Install unit level on structural curbs **OR** pilings, **as directed**. Coordinate wall penetrations and flashing with wall construction. Secure air-to-air energy recovery equipment to structural support with anchor bolts.
9. Install wind and seismic restraints according to manufacturers' written instructions. Wind and seismically restrained vibration isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
10. Suspended Units: Suspend and brace, **as directed**, units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
11. Install units with clearances for service and maintenance.
12. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.
13. Pipe drains from units and drain pans to nearest floor drain; use **ASTM B 88, Type L (ASTM B 88M, Type B)**, drawn-temper copper water tubing with soldered joints **OR** ASTM D 1785, Schedule 40 PVC pipe and solvent-welded fittings, **as directed**, same size as condensate drain connection.
  - a. Requirements for Low-Emitting Materials:
    - 1) Use PVC solvent cement that has a VOC content of 510 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
    - 2) Use adhesive primer that has a VOC content of 550 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

#### C. Connections

1. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to unit to allow service and maintenance.
3. Connect piping to units mounted on vibration isolators with flexible connectors.
4. Connect cooling condensate drain pans with air seal trap at connection to drain pan and install cleanouts at changes in pipe direction.
5. Chilled and Hot Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
6. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam And Condensate Heating Piping". Install shutoff valve at steam coil connections, float and thermostatic trap, and union or flange at each coil return connection.
7. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping".
8. Gas Piping: Comply with requirements in Division 23 Section(s) "Facility Natural-gas Piping" **OR** "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Make connection with AGA-approved flexible connectors.
9. Comply with requirements for ductwork specified in Division 23 Section "Metal Ducts".
10. Indirect-Fired Furnace Vent Connections: Comply with Division 23 Section "Breechings, Chimneys, And Stacks".
11. Electrical Connections: Comply with applicable requirements in Division 22.
  - a. Install electrical devices furnished with units but not factory mounted.

#### D. Field Quality Control

1. Perform tests and inspections.

2. Tests and Inspections:
    - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    - b. Adjust seals and purge.
    - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    - d. Set initial temperature and humidity set points.
    - e. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  3. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.
  4. Prepare test and inspection reports.
- E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 23 72 13 00

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Task	Specification	Specification Description
23 72 16 00	23 72 13 00	Air-To-Air Energy Recovery Units

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## SECTION 23 73 13 00 - MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for modular indoor central-station air-handling units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Constant-air-volume, single-zone air-handling units.
  - b. Constant-air-volume, multizone air-handling units.
  - c. Constant-air-volume, dual-duct air-handling units.
  - d. Variable-air-volume, single-zone air-handling units.
  - e. Variable-air-volume, dual-duct air-handling units.

#### C. Performance Requirements

1. Delegated Design: Design vibration isolation and seismic-restraint details, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Casing panels shall be self-supporting and capable of withstanding 133 percent of internal static pressures indicated, without panel joints exceeding a deflection of  $L/200$  **OR**  $L/100$ , **as directed**, where "L" is the unsupported span length within completed casings.
3. Seismic Performance: Air-handling units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### D. Submittals

1. Product Data: For each air-handling unit indicated.
  - a. Unit dimensions and weight.
  - b. Cabinet material, metal thickness, finishes, insulation, and accessories.
  - c. Fans:
    - 1) Certified fan-performance curves with system operating conditions indicated.
    - 2) Certified fan-sound power ratings.
    - 3) Fan construction and accessories.
    - 4) Motor ratings, electrical characteristics, and motor accessories.
  - d. Certified coil-performance ratings with system operating conditions indicated.
  - e. Dampers, including housings, linkages, and operators.
  - f. Filters with performance characteristics.
2. LEED Submittal:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Delegated-Design Submittal: For vibration isolation and seismic restraints, **as directed**, indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
  - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints, **as directed**, and for designing vibration isolation bases.



4. Seismic Qualification Certificates: For air-handling units, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Source quality-control reports.
6. Field quality-control reports.
7. Operation and maintenance data

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
3. ARI Certification: Air-handling units and their components shall be factory tested according to ARI 430, "Central-Station Air-Handling Units," and shall be listed and labeled by ARI.
4. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
5. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
6. Comply with NFPA 70.

## 1.2 PRODUCTS

### A. Unit Casings

1. General Fabrication Requirements for Casings:
  - a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
  - b. Casing Joints: Sheet metal screws or pop rivets.
  - c. Sealing: Seal all joints with water-resistant sealant.
  - d. Factory Finish for Steel and Galvanized-Steel Casings: Apply manufacturer's standard primer immediately after cleaning and pretreating.  
**OR**  
 Factory Finish for Steel and Galvanized-Steel Casings: Immediately after cleaning and pretreating, apply manufacturer's standard two-coat, baked-on enamel finish, consisting of prime coat and thermosetting topcoat.  
**OR**  
 Casing Coating: Thermoplastic vinyl **OR** Epoxy **OR** Zinc **OR** Synthetic resin **OR** Phenolic **OR** Polytetrafluoroethylene **OR** Vinyl ester **OR** Hot-dip galvanized **OR** Powder-baked enamel, **as directed**.
  - e. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Casing Insulation and Adhesive:
  - a. Materials: ASTM C 1071, Type I **OR** Type II, **as directed**.
  - b. Location and Application: Factory applied with adhesive and mechanical fasteners to the internal surface of section panels downstream from, and including, the cooling-coil section.
    - 1) Liner Adhesive: Comply with ASTM C 916, Type I.
    - 2) Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.

- 3) Liner materials applied in this location shall have air-stream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric depending on service-air velocity.
- OR**
- Location and Application: Encased between outside and inside casing.
3. Inspection and Access Panels and Access Doors:
    - a. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
    - b. Inspection and Access Panels:
      - 1) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement shall allow panels to be opened against air-pressure differential.
      - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
      - 3) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
    - c. Access Doors:
      - 1) Hinges: A minimum of two ball-bearing hinges or stainless-steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
      - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
      - 3) Fabricate windows in fan section doors of double-glazed, wire-reinforced safety glass with an air space between panes and sealed with interior and exterior rubber seals.
      - 4) Size: At least **18 inches (450 mm) OR 24 inches (600 mm), as directed**, wide by full height of unit casing up to a maximum height of **60 inches (1500 mm) OR 72 inches (1800 mm), as directed**.
    - d. Locations and Applications:
      - 1) Fan Section: Inspection and access panels **OR** Doors **OR** Doors and inspection and access panels, **as directed**.
      - 2) Access Section: Doors.
      - 3) Coil Section: Inspection and access panel.
      - 4) Damper Section: Inspection and access panels **OR** Doors, **as directed**.
      - 5) Filter Section: Inspection and access panels **OR** Doors, **as directed**, large enough to allow periodic removal and installation of filters.
      - 6) Mixing Section: Doors.
      - 7) Humidifier Section: Doors.
    - e. Service Light: 100-W vaporproof fixture with switched junction box located outside **OR** inside, **as directed**, adjacent to door.
      - 1) Locations: Each section accessed with door **OR** Fan section, **as directed**.
  4. Condensate Drain Pans:
    - a. Fabricated with one **OR** two, **as directed**, percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
      - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.1.
      - 2) Depth: A minimum of **2 inches (50 mm)** deep.
    - b. Formed sections **OR** Integral part of floor plating, **as directed**.
    - c. Single-wall, galvanized-steel **OR** stainless-steel, **as directed**, sheet.
 

**OR**

Double-wall, galvanized-steel **OR** stainless-steel, **as directed**, sheet with space between walls filled with foam insulation and moisture-tight seal.
    - d. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end **OR** both ends, **as directed**, of pan.
      - 1) Minimum Connection Size: **NPS 1 (DN 25) OR NPS 2 (DN 50), as directed**.
    - e. Pan-Top Surface Coating: Asphaltic waterproofing compound, for galvanized-steel drain pans.



- f. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.
- 5. Service Platform: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**, 42 inches (1070 mm) wide running entire length of unit and located on service access side, with angle side rails, 4-inch (100-mm) kick plates, and expanded metal floor. Provide platform with a fixed ladder that extends from the top of the side rail to the floor.
- 6. Air-Handling-Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
  - a. Seismic Fabrication Requirements: Fabricate mounting base and attachment to air-handling unit sections, accessories, and components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when air-handling unit frame is anchored to building structure.

**B. Fan, Drive, And Motor Section**

- 1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
  - a. Shafts: Designed for continuous operation at maximum-rated fan speed and motor horsepower, and with field-adjustable alignment.
    - 1) Turned, ground, and polished hot-rolled steel with keyway. Ship with a protective coating of lubricating oil.
    - 2) Designed to operate at no more than 70 percent of first critical speed at top of fan's speed range.
- 2. Centrifugal Fan Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
  - a. Bracing: Steel angle or channel supports for mounting and supporting fan scroll, wheel, motor, and accessories.
  - b. Horizontal-Flanged, Split Housing: Bolted construction.
  - c. Housing for Supply Fan: Attach housing to fan-section casing with metal-edged flexible duct connector.
  - d. Flexible Connector: Factory fabricated with a fabric strip 3-1/2 inches (89 mm) **OR** 5-3/4 inches (146 mm), **as directed**, wide attached to 2 strips of 2-3/4-inch- (70-mm-) wide, 0.028-inch- (0.7-mm-) thick, galvanized-steel sheet or 0.032-inch- (0.8-mm-) thick aluminum sheets; select metal compatible with casing.
    - 1) Flexible Connector Fabric: Glass fabric, double coated with neoprene. Fabrics, coatings, and adhesives shall comply with UL 181, Class 1.
      - a) Fabric Minimum Weight: 26 oz./sq. yd. (880 g/sq. m).
      - b) Fabric Tensile Strength: 480 lbf/inch (84 N/mm) in the warp and 360 lbf/inch (63 N/mm) in the filling.
      - c) Fabric Service Temperature: Minus 40 to plus 200 deg F (Minus 40 to plus 93 deg C).
- 3. Plenum Fan Housings: Steel frame and panel; fabricated without fan scroll and volute housing.
- 4. Backward-Inclined, Centrifugal Fan Wheels: Single-width-single-inlet and double-width-double-inlet construction with curved inlet flange, backplate, backward-inclined blades welded or riveted to flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

**OR**

Forward-Curved, Centrifugal Fan Wheels: Inlet flange, backplate, and shallow blades with inlet and tip curved forward in direction of airflow and mechanically fastened to flange and backplate; cast-steel hub swaged to backplate and fastened to shaft with set screws.

**OR**

Airfoil, Centrifugal Fan Wheels: Smooth-curved inlet flange, backplate, and hollow die-formed airfoil-shaped blades continuously welded at tip flange and backplate; cast-iron or cast-steel hub riveted to backplate and fastened to shaft with set screws.

**OR**

- Axial Fans: Fan wheel and housing, straightening-vane section, factory-mounted motor with belt drive or direct drive, an inlet cone section, and accessories.
- a. Variable-Pitch Fans: Internally mounted pneumatic **OR** electric **OR** electronic, **as directed**, actuator, externally mounted positive positioner, and mechanical-blade-pitch indicator.
  - b. Housings: Steel **OR** Galvanized steel **OR** Aluminum, **as directed**.
    - 1) Inlet and Outlet Connections: Flanges.
    - 2) Guide Vane Section: Integral guide vanes downstream from fan wheel designed to straighten airflow.
5. Fan Shaft Bearings:
- a. Lubricated and Sealed, Ball Bearings: Self-aligning, pillow-block type with a rated life of 50,000 **OR** 120,000, **as directed**, hours according to ABMA 9.  
**OR**  
Grease-Lubricated, Tapered-Roller Bearings: Self-aligning, pillow-block type with double-locking collars and 2-piece, cast-iron housing with grease lines extended to outside unit, **as directed**, and a rated life of 50,000 **OR** 120,000, **as directed**, hours according to ABMA 11.  
**OR**  
Grease-Lubricated Bearings: Self-aligning, pillow-block-type, ball or roller bearings with adapter mount and two-piece, cast-iron housing with grease lines extended to outside unit, **as directed**.
6. Belt Drives: Factory mounted, with adjustable alignment and belt tensioning, and with 1.5 **OR** 1.4 **OR** 1.3 **OR** 1.2, **as directed**, service factor based on fan motor.
- a. Pulleys: Cast iron or cast steel with split, tapered bushing; dynamically balanced at factory.
  - b. Motor Pulleys: Adjustable pitch for use with 5-hp motors and smaller; fixed pitch for use with motors larger than 5 hp. Select pulley size so pitch adjustment is at the middle of adjustment range at fan design conditions.
  - c. Belts: Oil resistant, nonsparking, and nonstatic; in matched sets for multiple-belt drives.
  - d. Belt Guards: Comply with requirements specified by OSHA and fabricate according to SMACNA's "HVAC Duct Construction Standards"; 0.1046-inch- (2.7-mm-) thick, 3/4-inch (20-mm) diamond-mesh wire screen, welded to steel angle frame; prime coated.
7. Variable-Inlet Vanes: Steel, with blades supported at both ends with permanently lubricated bearings. Variable mechanism terminating in single lever for connection to control actuator with connecting shaft for second set of variable inlet vanes on double-width fans.  
**OR**  
Discharge Dampers: Heavy-duty steel assembly with channel frame and sealed ball bearings, and opposed **OR** parallel, **as directed**, blades constructed of two plates formed around and welded to shaft, with blades linked out of air stream to single control lever.
8. Internal Vibration Isolation and Seismic Control, **as directed**: Fans shall be factory mounted with manufacturer's standard restrained, **as directed**, vibration isolation mounting devices having a minimum static deflection of 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.
- a. Seismic Fabrication Requirements: Fabricate fan section, internal mounting frame and attachment to fans, fan housings, motors, casings, accessories, and other fan section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when fan-mounting frame and air-handling-unit mounting frame are anchored to building structure.
9. Motor: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- a. Enclosure Type: Totally enclosed, fan cooled.
  - b. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
  - c. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

- d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 21.
- e. Mount unit-mounted disconnect switches on exterior **OR** interior, **as directed**, of unit.
- 10. Variable Frequency Controllers:
  - a. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
  - b. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range **OR** 66 Hz, with torque constant as speed changes **OR** 120 Hz, with horsepower constant throughout speed range, **as directed**.
  - c. Unit Operating Requirements:
    - 1) Input ac voltage tolerance of 208 V, plus or minus 5 **OR** 380 to 500 V, plus or minus 10 **OR** 525 to 575 V, plus or minus 10, **as directed**, percent.
    - 2) Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
    - 3) Minimum Efficiency: 96 percent at 60 Hz, full load.
    - 4) Minimum Displacement Primary-Side Power Factor: 96 percent.
    - 5) Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
    - 6) Starting Torque: 100 percent of rated torque or as indicated.
    - 7) Speed Regulation: Plus or minus 1 percent.
  - d. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
  - e. Internal Adjustability Capabilities:
    - 1) Minimum Speed: 5 to 25 percent of maximum rpm.
    - 2) Maximum Speed: 80 to 100 percent of maximum rpm.
    - 3) Acceleration: 2 to a minimum of 22 seconds.
    - 4) Deceleration: 2 to a minimum of 22 seconds.
    - 5) Current Limit: 50 to a minimum of 110 percent of maximum rating.
  - f. Self-Protection and Reliability Features:
    - 1) Input transient protection by means of surge suppressors.
    - 2) Undervoltage and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
    - 3) Adjustable motor overload relays capable of NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, performance.
    - 4) Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
    - 5) Instantaneous line-to-line and line-to-ground overcurrent trips.
    - 6) Loss-of-phase protection.
    - 7) Reverse-phase protection.
    - 8) Short-circuit protection.
    - 9) Motor overtemperature fault.
  - g. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
  - h. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
  - i. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
  - j. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
  - k. Door-mounted LED status lights shall indicate the following conditions:
    - 1) Power on.

- 2) Run.
- 3) Overvoltage.
- 4) Line fault.
- 5) Overcurrent.
- 6) External fault.
- l. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual-speed-control potentiometer and elapsed time meter.
- m. Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
  - 1) Output frequency (Hertz).
  - 2) Motor speed (rpm).
  - 3) Motor status (running, stop, fault).
  - 4) Motor current (amperes).
  - 5) Motor torque (percent).
  - 6) Fault or alarming status (code).
  - 7) Proportional-integral-derivative (PID) feedback signal (percent).
  - 8) DC-link voltage (volts direct current).
  - 9) Set-point frequency (Hertz).
  - 10) Motor output voltage (volts).
- n. Control Signal Interface:
  - 1) Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
  - 2) Remote signal inputs capable of accepting any of the following speed-setting input signals from the control system:
    - a) 0 to 10-V dc.
    - b) 0-20 or 4-20 mA.
    - c) Potentiometer using up/down digital inputs.
    - d) Fixed frequencies using digital inputs.
    - e) RS485.
    - f) Keypad display for local hand operation.
  - 3) Output signal interface with a minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
    - a) Output frequency (Hertz).
    - b) Output current (load).
    - c) DC-link voltage (volts direct current).
    - d) Motor torque (percent).
    - e) Motor speed (rpm).
    - f) Set-point frequency (Hertz).
  - 4) Remote indication interface with a minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
    - a) Motor running.
    - b) Set-point speed reached.
    - c) Fault and warning indication (overtemperature or overcurrent).
    - d) High- or low-speed limits reached.
- o. Communications: RS485 interface allows VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- p. Integral Disconnecting Means: NEMA AB 1, instantaneous-trip circuit breaker **OR** NEMA AB 1, molded-case switch **OR** NEMA KS 1, nonfusible switch **OR** NEMA KS 1, fusible switch, **as directed**, with lockable handle.
- q. Accessories:
  - 1) Devices shall be factory installed in controller enclosure unless otherwise indicated.
  - 2) Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
  - 3) Standard Displays:



- a) Output frequency (Hertz).
- b) Set-point frequency (Hertz).
- c) Motor current (amperes).
- d) DC-link voltage (volts direct current).
- e) Motor torque (percent).
- f) Motor speed (rpm).
- g) Motor output voltage (volts).

#### C. Coil Section

##### 1. General Requirements for Coil Section:

- a. Comply with ARI 410.
- b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
- c. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
- d. Coils shall not act as structural component of unit.
- e. Seismic Fabrication Requirements: Fabricate coil section, internal mounting frame and attachment to coils, and other coil section components with reinforcement strong enough to withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" when coil-mounting frame and air-handling-unit mounting frame are anchored to building structure.

##### 2. Electrical Heating Coils, Controls, and Accessories: Comply with UL 1995.

- a. Casing Assembly: Slip-in **OR** Flanged, **as directed**, type with galvanized-steel frame.
- b. Sheathed Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.

##### **OR**

Open Heating Elements: Resistance wire of 80 percent nickel and 20 percent chromium supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.

- c. Overtemperature Protection: Disk-type, automatically resetting, thermal-cutout, safety device; serviceable through terminal box without removing heater from coil section.
- d. Secondary Protection: Load-carrying, manually resetting or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
- e. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection.
  - 1) Magnetic **OR** Mercury, **as directed**, contactor.
  - 2) Solid-state, stepless pulse controller.
  - 3) Toggle switches, one per step.
  - 4) Step controller.
  - 5) Time-delay relay.
  - 6) Pilot lights, one per step.
  - 7) Airflow proving switch.

#### D. Air Filtration Section

##### 1. General Requirements for Air Filtration Section:

- a. Comply with NFPA 90A.
- b. Provide minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
- c. Provide filter holding frames arranged for flat or angular orientation, with access doors on both sides of unit. Filters shall be removable from one side or lifted out from access plenum.

##### 2. Disposable Panel Filters:

- a. Factory-fabricated, viscous-coated, flat-panel type.
- b. Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed.**
- c. Dust-Holding Capacity: as directed by the Owner.

- d. Initial Resistance: as directed by the Owner.
- e. Recommended Final Resistance: as directed by the Owner.
- f. Arrestance (ASHRAE 52.1): 80.
- g. Merv (ASHRAE 52.2): 5.
- h. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent, **as directed**.
- i. Frame: Galvanized steel, with metal grid on outlet side, steel rod grid on inlet side, hinged, and with pull and retaining handles.
3. Extended-Surface, Disposable Panel Filters:
  - a. Factory-fabricated, dry, extended-surface type.
  - b. Thickness: **1 inch (25 mm) OR 2 inches (50 mm) OR 4 inches (100 mm), as directed.**
  - c. Dust-Holding Capacity: as directed by the Owner.
  - d. Initial Resistance: as directed by the Owner.
  - e. Recommended Final Resistance: as directed by the Owner.
  - f. Arrestance (ASHRAE 52.1): 90.
  - g. Merv (ASHRAE 52.2): 7.
  - h. Media: Fibrous material formed into deep-V-shaped pleats with antimicrobial agent, **as directed**, and held by self-supporting wire grid.
  - i. Media-Grid Frame: Nonflammable cardboard **OR** Galvanized steel **OR** Fire-retardant, **3/4-inch (20-mm) particleboard with gaskets, as directed.**
  - j. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks.
4. Extended-Surface, Nonsupported-Media Filters:
  - a. Factory-fabricated, dry, extended-surface, self-supporting type.
  - b. Dust-Holding Capacity: as directed by the Owner.
  - c. Initial Resistance: as directed by the Owner.
  - d. Recommended Final Resistance: as directed by the Owner.
  - e. Arrestance (ASHRAE 52.1): 95.
  - f. Merv (ASHRAE 52.2): 13.
  - g. Media: Fibrous material with antimicrobial agent, **as directed**, constructed so individual pleats are maintained in tapered form by flexible internal supports under rated-airflow conditions.
  - h. Filter-Media Frame: Galvanized steel **OR** Hard polyurethane foam, **as directed**.
  - i. Mounting Frames: Welded, galvanized steel, with gaskets and fasteners, suitable for bolting together into built-up filter banks with space for prefilter, **as directed**.
5. Automatic Roll Filters:
  - a. Factory-fabricated, automatic, motor-driven, roll type.
  - b. Arrangement: Horizontal **OR** Vertical, **as directed**.
  - c. Dust-Holding Capacity: as directed by the Owner.
  - d. Initial Resistance: as directed by the Owner.
  - e. Recommended Final Resistance: as directed by the Owner.
  - f. Arrestance (ASHRAE 52.1): 80.
  - g. Merv (ASHRAE 52.2): 5.
  - h. Media: Compressed and rolled, fibrous-glass material viscous coated, and with antimicrobial agent, **as directed**.
  - i. Holding Frame: Galvanized steel, with enclosed, clean media roll arranged to allow upstream replacement of filter media.
  - j. Auxiliary Frame: Locate on downstream side of unit with downstream **OR** side, **as directed**, access.
  - k. Final Filter: Extended-surface, retained-media **OR** nonsupported-media **OR** HEPA, **as directed**, filters.
  - l. Control and Drive:
    - 1) Mechanism: Electric, gear-reducer, motor-driven, feed control equipped with manual media advance and runout switches for stopping media movement of filter bank and operating remote warning signal lights.



- 2) Manual Control: Manual switch to advance media and wired to override automatic controls.
  - 3) Automatic Control: Prewired control package to advance media when filter resistance exceeds adjustable high limit **OR** after adjustable operating time, **as directed**.
6. Activated-Carbon Panel Filters:
- a. Factory-fabricated unit with activated-carbon media.
  - b. Flat-Panel Media: Multilayer filter with inlet layer of polyester fibers, layer of activated-carbon granules bonded to fibers, layer of polyurethane foam, and housed in cardboard frame.
  - c. Pleated Media: Multilayer filter with inlet layer of cotton and synthetic fibers and layer of activated-carbon granules bonded to synthetic fibers, formed into deep-V-shaped pleats and held by self-wire grid, and housed in nonflammable cardboard frame.
  - d. Mounting Frames: Welded galvanized steel, with polyurethane gaskets and fasteners, capable of holding media and media frame in place and suitable for bolting together into built-up filter banks.
7. Activated-Carbon Filters:
- a. Factory-fabricated unit in deep-V arrangement with disposable panel prefilter.
  - b. Media: Activated carbon mounted in removable carbon-cell trays of epoxy-coated steel.
  - c. Activated-Carbon Capacity: **12 lb (5.4 kg)** of activated carbon per **500 cfm (236 L/s)** **OR** **8.8 lb (4.0 kg)** of activated carbon per **2000 cfm (944 L/s)**, **as directed**, of airflow.
  - d. Housing: **0.064-inch- (1.6-mm-)** thick, galvanized steel, for side servicing through gasketed access doors on both sides. Equip housings with metal slide channel tracks to hold activated-carbon trays.
8. HEPA Filters:
- a. Factory-fabricated unit.
  - b. Dust-Holding Capacity: as directed by the Owner.
  - c. Initial Resistance: as directed by the Owner.
  - d. Recommended Final Resistance: as directed by the Owner.
  - e. Arrestance (ASHRAE 52.1): 95 percent on 0.3-micrometer D.O.P. particles **OR** 99.97 percent on 0.3-micrometer D.O.P. particles **OR** 99.9995 percent on 0.1- and 0.2-micrometer D.O.P. particles **OR** 99.99995 percent on 0.1- and 0.2-micrometer D.O.P. particles, **as directed**.
  - f. Media: UL 586, fibrous glass, constructed of continuous sheets with closely spaced pleats with aluminum separators **OR** vinyl-coated aluminum separators **OR** separators of ribbons of filter media, **as directed**.
  - g. Frame Material: **3/4-inch- (19-mm-)** thick, fire-retardant plywood **OR** **3/4-inch- (19-mm-)** thick, fire-retardant particleboard **OR** **3/4-inch- (19-mm-)** thick plywood **OR** **3/4-inch- (19-mm-)** thick particleboard **OR** Galvanized steel **OR** Aluminized steel **OR** Cadmium-plated steel **OR** Stainless steel **OR** Aluminum, **as directed**.
  - h. Media to Frame Side Bond: Polyurethane foam **OR** Silicone **OR** Neoprene adhesive **OR** Fiberglass-mat packing **OR** Thermosetting sealant **OR** Knife edge in fluid-filled channel, **as directed**.
  - i. Face Gasket: Neoprene expanded rubber **OR** Ceramic fiber **OR** Silicone, **as directed**.
  - j. Mounting Frames: Downstream corners of holding device shall have cushion pads to protect media. Bolted filter-sealing mechanism shall mount and continuously seal each individual filter.
9. Filter Gage:
- a. **3-1/2-inch- (90-mm-)** **OR** **2-inch- (50-mm-)**, **as directed**, diameter, diaphragm-actuated dial in metal case.
  - b. Vent valves.
  - c. Black figures on white background.
  - d. Front recalibration adjustment.
  - e. **2 OR 3, as directed**, percent of full-scale accuracy.

- f. Range: 0- to 0.5-inch wg (0 to 125 Pa) OR 0- to 1.0-inch wg (0 to 250 Pa) OR 0- to 2.0-inch wg (0 to 500 Pa) OR 0- to 3.0-inch wg (0 to 750 Pa) OR 0- to 4.0-inch wg (0 to 1000 Pa), as directed.
- g. Accessories: Static-pressure tips with integral compression fittings, 1/4-inch (6-mm) aluminum OR plastic, as directed, tubing, and 2- or 3-way vent valves.

E. Dampers

1. General Requirements for Dampers: Leakage rate, according to AMCA 500, "Laboratory Methods for Testing Dampers for Rating," shall not exceed 2 percent of air quantity at 2000-fpm (10-m/s) face velocity through damper and 4-inch wg (1000-Pa) pressure differential.
2. Damper Operators: Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac".  
OR  
Electronic Damper Operators:
  - a. Direct-coupled type designed for minimum 60,000 full-stroke cycles at rated torque.
  - b. Electronic damper position indicator shall have visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.
  - c. Operator Motors:
    - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Work Results For Hvac".
    - 2) Size to operate with sufficient reserve power to provide smooth modulating action or two-position action.
    - 3) Permanent Split-Capacitor or Shaded-Pole Type: Gear trains completely oil immersed and sealed. Equip spring-return motors with integral spiral-spring mechanism in housings designed for easy removal for service or adjustment of limit switches, auxiliary switches, or feedback potentiometer.
  - d. Nonspring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running torque of 150 in. x lbf (16.9 N x m) and breakaway torque of 300 in. x lbf (33.9 N x m).
  - e. Spring-Return Motors for Dampers Larger Than 25 Sq. Ft. (2.3 sq. m): Size for running and breakaway torque of 150 in. x lbf (16.9 N x m).
  - f. Size dampers for running torque calculated as follows:
    - 1) Parallel-Blade Damper with Edge Seals: 7 inch-lb/sq. ft. (86.8 kg-cm/sq. m) of damper.
    - 2) Opposed-Blade Damper with Edge Seals: 5 inch-lb/sq. ft. (62 kg-cm/sq. m) of damper.
    - 3) Parallel-Blade Damper without Edge Seals: 4 inch-lb/sq. ft. (49.6 kg-cm/sq. m) of damper.
    - 4) Opposed-Blade Damper without Edge Seals: 3 inch-lb/sq. ft. (37.2 kg-cm/sq. m) of damper.
    - 5) Dampers with 2- to 3-Inch wg (500 to 750 Pa) of Pressure Drop or Face Velocities of 1000 to 2500 fpm (5 to 13 m/s): Increase running torque by 1.5.
    - 6) Dampers with 3- to 4-Inch wg (750 to 1000 Pa) of Pressure Drop or Face Velocities of 2500 to 3000 fpm (13 to 15 m/s): Increase running torque by 2.0.
  - g. Coupling: V-bolt and V-shaped, toothed cradle.
  - h. Overload Protection: Electronic overload or digital rotation-sensing circuitry.
  - i. Fail-Safe Operation: Mechanical, spring-return mechanism with external, manual gear release on nonspring-return actuators.
  - j. Power Requirements (Two-Position Spring Return): 24 OR 120 OR 230, as directed, -V ac.
  - k. Power Requirements (Modulating): Maximum 10 VA at 24-V ac or 8 W at 24-V dc.
  - l. Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
  - m. Temperature Rating: Minus 22 to plus 122 deg F (Minus 30 to plus 50 deg C) OR 40 to 104 deg F (5 to 40 deg C), as directed.



- n. Run Time: 12 seconds open, 5 seconds closed **OR** 30 seconds **OR** 60 seconds **OR** 120 seconds, **as directed**.
- OR**
- Pneumatic Damper Operators:
  - a. Rolling-diaphragm piston type with adjustable stops and spring return, sized to operate with sufficient reserve power to provide smooth modulating action or two-position action. Where actuators operate in sequence, provide pilot positioners.
  - b. Pneumatic Damper Position Indicator: Potentiometer mounted in enclosure with adjustable crank-arm assembly connected to damper to transmit 0 to 100 percent valve/damper travel.
  - c. Pilot Positioners:
    - 1) Start Point: Adjustable from 2 to 12 psig (14 to 83 kPa).
    - 2) Operating Span: Adjustable from 5 to 13 psig (35 to 90 kPa).
    - 3) Linearity: Plus or minus 10 percent of output signal span.
    - 4) Hysteresis: 3 percent of span.
    - 5) Response: 0.25-psig (1723-Pa) input change.
    - 6) Maximum Pilot Signal Pressure: 20 psig (140 kPa).
    - 7) Maximum Control Air-Supply Pressure: 60 psig (410 kPa).
  - d. Actuator Housing: Molded or die-cast zinc or aluminum. Terminal unit actuators may be high-impact plastic with ambient temperature rating of 50 to 140 deg F (10 to 60 deg C) unless located in return-air plenums, **as directed**.
  - e. Inlet-Vane Operators: High pressure, with pilot positioners.
- 3. Zone Dampers: Two single-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers offset 90 degrees from each other on cadmium-plated, **as directed**, steel operating rod rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
- 4. Face-and-Bypass Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with cadmium-plated, **as directed**, steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame and with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
- 5. Outdoor- and Return-Air Mixing Dampers: Parallel-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers mechanically fastened to cadmium-plated, **as directed**, steel operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
- 6. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade **OR** parallel-blade, **as directed**, arrangement with cadmium-plated, **as directed**, steel operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed 5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).
- 7. Mixing Section: Multiple-blade, air-mixer assembly located immediately downstream of mixing section.
- 8. Combination Filter and Mixing Section:
  - a. Cabinet support members shall hold 2-inch- (50-mm-) thick, pleated, flat, permanent or throwaway filters.
  - b. Multiple-blade, air-mixer assembly shall mix air to prevent stratification, located immediately downstream of mixing box.

#### F. Humidifiers

- 1. Steam Grid Humidifier:
  - a. Manifold:



- 1) ASTM A 666, Type 304 stainless steel.
- 2) Steam jacketed.
- 3) Insulated with 1/2-inch (13-mm) fiberglass and stainless-steel jacket.
- 4) Manifold shall extend the full width of unit with mounting brackets at ends.
- b. Steam Separator: Cast iron, **OR** ASTM A 666, Type 304 stainless steel, **as directed**, with separate, **as directed**, humidifier control valve.
- c. Humidifier Control Valve: Actuator: Pneumatic **OR** Electric, **as directed**, modulating with spring return.  
**OR**  
Humidifier Control Valve: Actuator: As specified in Division 23 Section "Instrumentation And Control For Hvac".
- d. Steam Trap: Inverted-bucket type, sized for a minimum of three times the maximum rated condensate flow of humidifier at 1/2-psig (3.4-kPa) inlet pressure.
- e. Aquastat: For separate mounting on steam condensate, return piping to prevent cold operation of humidifier.
- f. Strainer: In-line type.
- g. Airflow Switch: To prevent humidifier operation in the absence of airflow.
2. Wet Glass Cell Washer Section:
  - a. 3-inch- (75-mm-) deep cells with random packed, glass-fiber media in galvanized-steel **OR** stainless-steel, **as directed**, frames.
  - b. Access Door: Watertight with brass fittings, wire glass window, **as directed**, and locking handles.
  - c. Spray Tree Assembly: Brass **OR** Stainless-steel, **as directed**, nozzles and galvanized-steel **OR** stainless-steel, **as directed**, piping.
  - d. Eliminator: Galvanized-steel **OR** Stainless-steel, **as directed**, plates.
  - e. Tank:
    - 1) Welded steel **OR** stainless steel, **as directed**, with interior and exterior surfaces blasted and painted with zinc-chromate paint, **as directed**.
    - 2) Copper suction screen.
    - 3) Drain, overflow, and suction connections.
    - 4) Makeup connection with brass, **as directed**, float valve, and with quick-fill connection.
  - f. Insulate exterior with duct insulation and mount on 2-inch (-50-mm-) thick, rigid insulation board.
3. Evaporative Humidifier Section:
  - a. Access Door: Watertight cast iron, **as directed**, with brass fittings, wire glass window, and locking handles.
  - b. Spray Tree Assembly: Brass nozzles and galvanized piping, galvanized eliminator plates with flooding nozzles and header, and galvanized antisplash baffles **OR** cross-fluted cellulose media, **as directed**.
  - c. Tank:
    - 1) Welded steel tank with interior and exterior surfaces blasted and painted with zinc-chromate paint.
    - 2) Copper suction screen, drain, overflow, and suction connections.
    - 3) Makeup connection with brass, **as directed**, float valve, and with quick-fill connection.
  - d. Insulation: Insulate with duct insulation on exterior and mount on 2-inch (-50-mm-) thick, rigid insulation board.
- G. Air-To-Air Energy Recovery
  1. Heat Wheels:
    - a. Casing:
      - 1) Steel, with manufacturer's standard paint coating.
      - 2) Integral purge section limiting carryover of exhaust air to between 0.05 percent at 1.6-inch wg and 0.20 percent at 4-inch wg (0.05 percent at 400-Pa and 0.20 percent at 1000-Pa) differential pressure.



- 3) Casing seals on periphery of rotor, on duct divider, and on purge section.
- 4) Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.
- b. Rotor: Aluminum, segmented wheel, strengthened with radial spokes, with nontoxic, noncorrosive, silica-gel desiccant coating, **as directed**. Construct media for passing maximum 500 **OR** 800 **OR** 1200, **as directed**, -micrometer solids.  
**OR**  
Rotor: Glass-fiber **OR** Polymer, **as directed**, segmented wheel, strengthened with radial spokes impregnated with nonmigrating, water-selective, molecular-sieve desiccant coating. Construct media for passing maximum 800 **OR** 1200, **as directed**, -micrometer solids.
- c. Drive: Fractional horsepower motor and gear reducer, with speed changed by variable frequency controller, **as directed**, and self-adjusting multilink belt around outside of rotor.
- d. Controls:
  - 1) Starting relay, factory mounted and wired, and manual motor starter for field wiring.
  - 2) Variable frequency controller, factory mounted and wired, permitting input of field connected 4-20 mA or 1-10-V control signal.  
**OR**  
Variable frequency controller, factory mounted and wired, with exhaust-air sensor to vary rotor speed and maintain exhaust temperature above freezing.  
**OR**  
Variable frequency controller, factory mounted and wired, with exhaust- and outdoor-air sensors, automatic changeover thermostat and set-point adjuster, to vary rotor speed and maintain exhaust temperature above freezing, **as directed**, and air differential temperature above set point. Provide maximum rotor speed when exhaust-air temperature is less than outdoor-air temperature.
  - 3) Pilot-Light Indicator: Display rotor rotation and speed.
  - 4) Speed Settings: Adjustable settings for maximum and minimum rotor speed limits.
2. Fixed-Plate Sensible Heat Exchangers:
  - a. Casing: Aluminum **OR** Galvanized steel **OR** Enameled steel, with galvanized-steel liner **OR** Enameled steel, **as directed**.
  - b. Plates: Evenly spaced and sealed and arranged for counter airflow.
  - c. Plate Material: Embossed aluminum **OR** Stainless steel **OR** Polypropylene copolymer (high-density plastic), **as directed**.
    - 1) Plate Coating: Epoxy **OR** Air-dried phenolic, **as directed**.
  - d. Bypass: Plenum within casing, with gasketed face-and-bypass dampers that have operating rods extended outside casing.
  - e. Water Wash: Automatic system, with spray manifold to individual spray tubes or traversing type with stainless-steel-screw operating mechanism and electric motor drive; activated by time clock, with detergent injection, **as directed**.
  - f. Heat-Exchanger Prefilters: 1 inch (25 mm) thick, disposable **OR** 2 inches (50 mm) thick, disposable **OR** Medium efficiency **OR** Electrostatic, **as directed**.
- H. Source Quality Control
  1. Fan Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Fans shall bear AMCA-certified sound ratings seal.
  2. Fan Performance Rating: Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency. Rate performance according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating."
  3. Water Coils: Factory tested to 300 psig (2070 kPa) according to ARI 410 and ASHRAE 33.
  4. Steam Coils: Factory tested to 300 psig (2070 kPa) and to 200 psig (1380 kPa) underwater according to ARI 410 and ASHRAE 33.
  5. Refrigerant Coils: Factory tested to 450 psig (3105 kPa) according to ARI 410 and ASHRAE 33.



### 1.3 EXECUTION

#### A. Installation

1. Equipment Mounting: Install air-handling units on concrete bases using elastomeric pads **OR** using elastomeric mounts **OR** using restrained spring isolators **OR** without vibration isolation devices, **as directed**. Secure units to anchor bolts installed in concrete bases. Comply with requirements for concrete bases specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/2 inch (13 mm) OR 1 inch (25 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed.**
  - b. Install galvanized-steel **OR** stainless-steel, **as directed**, plate to equally distribute weight over elastomeric pad.
  - c. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - d. Install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - e. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - f. Install anchor bolts to elevations required for proper attachment to supported equipment.

**OR**

Equipment Mounting: Install air-handling unit using elastomeric pads **OR** using elastomeric mounts **OR** using restrained spring isolators **OR** without vibration isolation devices, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

  - g. Minimum Deflection: **1/4 inch (6 mm) OR 1/2 inch (13 mm) OR 1 inch (25 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed.**
  - h. Install galvanized-steel **OR** stainless-steel, **as directed**, plate to equally distribute weight over elastomeric pad.
2. Suspended Units: Suspend and brace, **as directed**, units from structural-steel support frame using threaded steel rods and spring hangers. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Arrange installation of units to provide access space around air-handling units for service and maintenance.
4. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.
5. Install filter-gage, static-pressure taps upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum in accessible position. Provide filter gages on filter banks, installed with separate static-pressure taps upstream and downstream of filters.

#### B. Connections

1. Comply with requirements for piping specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to air-handling unit to allow service and maintenance.
3. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
4. Connect condensate drain pans using **NPS 1-1/4 (DN 32), ASTM B 88, Type M (ASTM B 88M, Type C)** copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
5. Hot- and Chilled-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Install shutoff valve and union or flange at each coil supply connection. Install balancing valve and union or flange at each coil return connection.
6. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam And Condensate Heating Piping". Install shutoff valve at steam supply connections, float and thermostatic trap, and union or flange at each coil return connection. Install gate valve and



inlet strainer at supply connection of dry steam humidifiers, and inverted bucket steam trap to condensate return connection.

7. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping". Install shutoff valve and union or flange at each supply and return connection.
8. Connect duct to air-handling units with flexible connections. Comply with requirements in Division 23 Section "Air Duct Accessories".

C. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
  - a. Leak Test: After installation, fill water and steam coils with water, and test coils and connections for leaks.
  - b. Charge refrigerant coils with refrigerant and test for leaks.
  - c. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - d. Automatic-Roll-Filter Operational Test: Operate filters to demonstrate compliance with requirements. Test for leakage of unfiltered air while system is operating.
  - e. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter with soapy water to check for air leaks.
  - f. HEPA-Filter Operational Test: Pressurize housing to a minimum of 3-inch wg (750 Pa) or to designed operating pressure, whichever is higher; test housing joints, door seals, and sealing edges of filter for air leaks according to ASME N510, pressure-decay method.
  - g. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
4. Prepare test and inspection reports.

D. Startup Service

1. Perform startup service.
  - a. Complete installation and startup checks according to manufacturer's written instructions.
  - b. Verify that shipping, blocking, and bracing are removed.
  - c. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
  - d. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
  - e. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
  - f. Verify that zone dampers fully open and close for each zone.
  - g. Verify that face-and-bypass dampers provide full face flow.
  - h. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
  - i. Comb coil fins for parallel orientation.
  - j. Verify that proper thermal-overload protection is installed for electric coils.
  - k. Install new, clean filters.
  - l. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
2. Starting procedures for air-handling units include the following:
  - a. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace fan and motor pulleys as required to achieve design conditions, **as directed**.
  - b. Measure and record motor electrical values for voltage and amperage.

- c. Manually operate dampers from fully closed to fully open position and record fan performance.
- E. Adjusting
  - 1. Adjust damper linkages for proper damper operation.
  - 2. Comply with requirements in Division 23 Section "Testing, Adjusting, And Balancing For Hvac" for air-handling system testing, adjusting, and balancing.
- F. Cleaning
  - 1. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.
- G. Demonstration
  - 1. Train Owner's maintenance personnel to adjust, operate, and maintain air-handling units.

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Task	Specification	Specification Description
23 73 13 00	07 72 23 00	Roof Accessories

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## SECTION 23 74 16 13 - ROOFTOP REPLACEMENT AIR UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for rooftop replacement-air units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes cooling-only and cooling and heating rooftop replacement-air units.

#### C. Definitions

1. DDC: Direct-digital controls.

#### D. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. Shop Drawings: Include details of installation and wiring diagrams.
3. Coordination Drawings: Rooftop replacement-air units to roof-curb mounting details drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - a. Size and location of rooftop replacement-air unit mounting rails and anchor points and methods for anchoring units to roof curb.
  - b. Required roof penetrations for ducts, pipes, and electrical raceways, including size and location of each penetration.
4. Startup service reports.
5. Operation and maintenance data.
6. Warranty: Special warranty specified in this Section.
7. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

#### F. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to replace components listed below that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Compressors: Manufacturer's standard, but not less than five years from date of Final Completion.
  - b. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five **OR** 10, **as directed**, years from date of Final Completion.



## 1.2 PRODUCTS

### A. Cabinet

1. Construction: Single **OR** Double, **as directed**, wall.
2. Exterior Casing: Galvanized steel with baked-enamel paint finish and **OR** Stainless steel, **as directed**, with lifting lugs and knockouts for electrical and piping connections.
3. Interior Casing: Galvanized-steel **OR** Stainless steel, **as directed**.
4. Base Rails: Galvanized-steel **OR** Stainless-steel, **as directed**, rails for mounting on roof curb.
5. Service Doors: Hinged access doors with neoprene gaskets.
6. Internal Insulation: Fibrous-glass duct lining complying with ASTM C 1071, Type II.
  - a. Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed**.
  - b. Insulation Adhesive: Comply with ASTM C 916, Type I.
  - c. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner and without causing air leakage when applied as recommended by manufacturer.
7. Condensate Drain Pans: Formed sections of galvanized-steel **OR** stainless-steel, **as directed**, sheet designed for self-drainage. Fabricate pans and drain connection to comply with ASHRAE 62.1.
8. Roof Curb: Full-perimeter curb of sheet metal, minimum **8 inches (200 mm) OR 12 inches (300 mm) OR 16 inches (400 mm), as directed**, high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
9. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

### B. Supply-Air Fan

1. Fan: Forward-curved centrifugal; statically and dynamically balanced, galvanized **OR** coated, **as directed**, steel, mounted on solid-steel shaft with self-aligning, permanently lubricated ball bearings **OR** pillow-block bearings rated L<sub>50</sub> for 200,000 hours and having external grease fittings, **as directed**.
2. Motor: Open dripproof **OR** Totally enclosed, **as directed**, single-speed **OR** two-speed, **as directed**, motor.
3. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly with minimum 1.4 service factor.
4. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, **as directed**, elastomeric **OR** spring, **as directed**, isolators.

### C. Refrigeration System

1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Code for Mechanical Refrigeration."
2. Compressors: Reciprocating **OR** Scroll, **as directed**, compressors with integral vibration isolators, internal overcurrent and overtemperature protection, internal pressure relief, and crankcase heater, **as directed**.
3. Minimum Efficiency: As defined by ASHRAE/IESNA 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."
4. Refrigerant: R-407C **OR** R-410A, **as directed**.
5. Refrigeration System Specialties:
  - a. Expansion valve with replaceable thermostatic element.
  - b. Refrigerant dryer.
  - c. High-pressure switch.
  - d. Low-pressure switch.
  - e. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
  - f. Brass service valves installed in discharge and liquid lines.
  - g. Operating charge of refrigerant.

6. Capacity Control: Hot-gas bypass refrigerant control for capacity control with continuous dehumidification on a single compressor.  
**OR**  
 Capacity Control: Patented, Rawal APR control with zero to 100 percent modulating capacity control using hot-gas bypass. Evaporator coil shall be continuously active for dehumidification.  
**OR**  
 Capacity Control: Single compressor with evaporator and condenser coil within the refrigerant section to provide initial precooling and reheat for humidity control.  
**OR**  
 Capacity Control: Heat-pipe heat exchanger shall wrap around the evaporator coil to precool the air entering the evaporator coil, and reheat the air leaving the evaporator coil to control humidity.
  7. Refrigerant Coils: Evaporator and condenser **OR** Evaporator, condenser, and reheat condenser, **as directed**, coils shall be designed, tested, fabricated, and rated according to ARI 410 and ASHRAE 33. Coils shall be leak tested under water with air at **315 psig (2170 kPa)**.
    - a. Capacity Reduction: Circuit coils for face **OR** row **OR** interleaved, **as directed**, control.
    - b. Tubes: Copper.
    - c. Fins: Aluminum **OR** Copper, **as directed**, with minimum fin spacing of **0.071 inch (1.81 mm)**, **as directed**.
    - d. Fin and Tube Joint: Mechanical bond.
    - e. Suction and Distributor: Seamless copper tube with brazed joints.
    - f. Coating: Phenolic epoxy corrosion-protection coating on both coils.
    - g. Source Quality Control: Test to **450 psig (3105 kPa)**, and to **300 psig (2070 kPa)** underwater.
  8. Condenser Fan: Propeller type, directly driven by motor.
  9. Safety Controls:
    - a. Compressor motor and outside-coil fan motor low ambient lockout.
    - b. Overcurrent protection for compressor motor and outside-coil fan motors.
- D. Direct-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code"; ANSI Z83.4, "Non-Recirculating Direct Gas-Fired Industrial Air Heaters"; and ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters," for direct-fired gas furnace.
  2. Burners: Cast-iron burner with stainless-steel mixing plates.
    - a. Rated for a maximum turndown ratio of 30:1.
    - b. Fuel: Natural **OR** Propane, **as directed**, gas.
  3. Safety Controls:
    - a. Gas manifold safety switches and controls shall comply with ANSI standards and FMG **OR** and IRI, **as directed**.
    - b. Pilot: Intermittent spark igniter.
    - c. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
    - d. External gas-pressure regulator shall regulate pressure to not more than **0.5 psig (3.4 kPa)**.
    - e. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
    - f. Manual-Reset, High-Limit Switch: Stops burner and closes main gas valve if high-limit temperature is exceeded.
    - g. Gas Train: Redundant, main gas valves, electric pilot valve, main and pilot gas-pressure regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas-pressure switches **OR** to comply with FMG requirements **OR** to comply with IRI requirements, **as directed**.
- E. Indirect-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; complying with NFPA 54, "National Fuel Gas Code," and ANSI Z21.47, "Gas-Fired Central Furnaces."
    - a. AGA Approval: Designed and certified by and bearing label of AGA.

2. Burners: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed**.
  - a. Minimum AFUE: **<Insert value>** percent.  
**OR**  
Minimum Thermal Efficiency: **<Insert value>** percent.  
**OR**  
Minimum Combustion Efficiency: **<Insert value>** percent.
  - b. Fuel: Natural **OR** Propane, **as directed**, gas.
  - c. Ignition: Electronically controlled electric spark with flame sensor.
  - d. High-Altitude Model **OR** Kit, **as directed**: For Project elevations more than **2000 feet (610 m)** above sea level.
3. Heat-Exchanger Drain Pan: Stainless steel.
4. Venting: Gravity vented.  
**OR**  
Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
5. Safety Controls:
  - a. Gas Control Valve: Single stage **OR** Two stage **OR** Electronic modulating, **as directed**.
  - b. Gas Train: Single-body, regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff.

F. Electric-Resistance Heating

1. Electric-Resistance Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.  
**OR**  
Electric-Resistance Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings, fastened to supporting brackets, and mounted in galvanized-steel frame.
  - a. Heating Capacity: Low density **35 W per sq. in. (54 kW per sq. m)**, factory wired for single-point wiring connection; with time delay for element staging, and overcurrent and overheat protective devices.
  - b. Safety Controls:
    - 1) Blower-motor interlock, air-pressure switch.
    - 2) Quiet mercury contactors.
    - 3) Time delay between steps.
    - 4) Integral, nonfused power disconnect switch.

G. Heating Coils

1. Hot-Water Coils: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**, coil fabricated and tested according to ARI 410 with aluminum fins and seamless copper tube in galvanized-steel **OR** stainless-steel, **as directed**, casing.
  - a. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
  - b. Control valves are specified in Division 23 Section "Instrumentation And Control For Hvac".
2. Steam Coils: Distributing coil fabricated and tested according to ARI 410, with threaded steam supply and condensate connections. Nonfreeze type having aluminum-plate fin and seamless copper double tube in galvanized-steel casing, pitched for proper drainage; tested to **150 psig (1035 kPa)** and leak tested to **100 psig (690 kPa)** with air under water.
  - a. Control valves are specified in Division 23 Section "Instrumentation And Control For Hvac".

H. Cooling Coils

1. Chilled-Water Coils: Continuous-circuit **OR** Self-draining **OR** Cleanable, **as directed**, coil fabricated and tested according to ARI 410 with aluminum fins and seamless copper tube in galvanized-steel **OR** stainless-steel, **as directed**, casing.

- a. Headers: Cast iron with drain and air vent tappings **OR** Cast iron with cleaning plugs, and drain and air vent tappings **OR** Seamless copper tube with brazed joints, prime coated **OR** Fabricated steel with brazed joints, prime coated, **as directed**.
  - b. Control valves are specified in Division 23 Section "Instrumentation And Control For Hvac".
- I. Outdoor-Air Intake And Dampers
  1. Dampers: Leakage rate, according to AMCA 500, shall not exceed 2 percent of air quantity at face velocity of **2000 fpm (10 m/s)** through damper and pressure differential of **4-inch wg (1000 Pa)**.
  2. Damper Operators: Electric.
  3. Mixing Boxes: Parallel-blade, galvanized-steel dampers mechanically fastened to steel operating rod inside cabinet. Connect operating rods with common interconnecting linkages so dampers operate simultaneously.
  4. Outdoor-Air Intake Hoods: Galvanized-steel **OR** Stainless steel, **as directed**, with bird screen complying with ASHRAE 62.1 and finish to match cabinet.
- J. Filters
  1. Comply with NFPA 90A.
  2. Cleanable Filters: **2-inch- (50-mm-)** thick, cleanable metal mesh.  
**OR**  
Disposable Panel Filters: **2-inch- (50-mm-)** thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1, **as directed**.
    - a. Media: Interlaced glass fibers sprayed with nonflammable adhesive.
    - b. Frame: Galvanized steel.
- K. Controls
  1. Factory-wire connection for controls' power supply.
  2. Control devices, including sensors, transmitters, relays, switches, thermostats, humidistats, detectors, operators, actuators, and valves, shall be manufacturer's standard items to accomplish indicated control functions.
  3. Unit Controls: Solid-state control board and components with field-adjustable control parameters.
  4. Supply-Fan Control: Units shall be electrically interlocked with corresponding exhaust fans, to operate continuously when exhaust fans are running. Time clock shall switch operation from occupied to unoccupied. Night setback thermostat shall cycle fan during unoccupied periods to maintain space temperature.
    - a. Timer: Seven-day electronic clock.
    - b. Electrically interlock kitchen hood fire-extinguishing system to de-energize replacement-air unit when fire-extinguishing system discharges.
  5. Remote **OR** Unit, **as directed**, -Mounted Status Panel:
    - a. Cooling/Off/Heating Controls: Control operational mode.
    - b. Damper Position: Indicates position of outdoor-air dampers in terms of percentage of outdoor air.
    - c. Status Lights:
      - 1) Filter dirty.
      - 2) Fan operating.
      - 3) Cooling operating.
      - 4) Heating operating.
  6. Refrigeration System Controls:
    - a. Unit-mounted enthalpy controller shall lock out refrigerant system when outdoor-air enthalpy is less than **28 Btu/lb (65 kJ/kg)** of dry air or outdoor-air temperature is less than **60 deg F (15 deg C)**.
    - b. Outdoor-air sensor de-energizes dehumidifier operation when outdoor-air temperature is less than **60 deg F (15 deg C)**.
    - c. Wall-mounting, relative-humidity sensor energizes dehumidifier operation when relative humidity is more than 60 percent.



7. Heating Controls:
  - a. Factory-mounted sensor in supply-fan outlet **OR** Remote-mounting sensor for field installation in supply-air duct, **as directed**, with sensor adjustment located in control panel modulates gas furnace burner to maintain space temperature.
  - b. Wall-mounting, space-temperature sensor with temperature adjustment **OR** unit-mounted temperature adjustment **OR** adjustment on remote-control panel, **as directed**, that modulates gas furnace burner to maintain space temperature.
  - c. Remote Setback Thermostat: Adjustable room thermostat selected by timer, set at **50 deg F (10 deg C)**; cycles supply fan and gas furnace burner to maintain space temperature.
  - d. Staged Burner Control: Two **OR** Four, **as directed**, steps of control.  
**OR**  
Electromechanical or Electronic Burner Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual furnace units.
8. Electric-Resistance Heating Controls: Wall-mounting thermostat controls SCR **OR** sequences stages, **as directed**.
9. Damper Controls:
  - a. Wall-mounting pressure sensor modulates outdoor- and return-air dampers to maintain a positive pressure in space served by rooftop replacement-air unit at minimum **0.05-inch wg (12.4 Pa)**.
  - b. When exhaust fans stop, set outdoor- and return-air damper to 75 **OR** 50 **OR** 25, **as directed**, percent outdoor air. When exhaust fans start, close return-air damper and fully open outdoor-air damper.
10. Integral Smoke Alarm: Smoke detector installed in supply and return air.
11. DDC Temperature Control: Stand-alone control module for link between unit controls and DDC temperature-control system. Control module shall be compatible with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac". Links shall include the following:
  - a. Start/stop interface relay, and relay to notify DDC temperature-control system alarm condition.
  - b. Hardware interface or additional sensors for the following:
    - 1) Room temperature.
    - 2) Discharge air temperature.
    - 3) Refrigeration system operating.
    - 4) Furnace operating.

L. Motors

1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

### 1.3 EXECUTION

A. Installation

1. Install roof curb on roof structure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install and secure rooftop replacement-air units on curbs and coordinate roof penetrations and flashing with roof construction.  
**OR**  
Install restrained vibration isolation roof-curb rails on roof structure according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts" **OR** ARI Guideline B, **as directed**. Install and secure rooftop replacement-air units on rails and coordinate roof penetrations and flashing with roof construction. Restrained isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".



2. Install wall- and duct-mounting sensors, thermostats, and humidistats furnished by manufacturers for field installation. Install control wiring and make final connections to control devices and unit control panel.
  3. Install **3000-psi (20.7-MPa)**, compressive strength (28-day) concrete base inside roof curb, **4 inches (100 mm)** thick. Concrete and reinforcement are specified in Division 31.
- B. Connections
1. Piping installation requirements are specified in other Division 21-. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to machine to allow service and maintenance.
    - a. Gas Burner Connections: Comply with requirements in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping to burner, full size of gas train inlet, and connect with union, pressure regulator, **as directed**, and shutoff valve with sufficient clearance for burner removal and service.
    - b. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
    - c. Steam Coil Connections: Comply with requirements in Division 23 Section "Steam And Condensate Heating Piping". Connect to steam piping with shutoff valve and union or flange; for condensate piping, starting from the coil connection, connect with union or flange, strainer, trap, and shutoff valve.
  3. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to rooftop replacement-air units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".
  4. Electrical Connections: Comply with requirements in Division 22 for power wiring, switches, and motor controls.
  5. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
- C. Startup Service
1. Engage a factory-authorized service representative to perform startup service.
  2. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
    - a. Inspect for visible damage to furnace combustion chamber.
    - b. Inspect for visible damage to compressor, air-cooled outside coil, and fans.
    - c. Inspect casing insulation for integrity, moisture content, and adhesion.
    - d. Verify that clearances have been provided for servicing.
    - e. Verify that controls are connected and operable.
    - f. Verify that filters are installed.
    - g. Clean outside coil and inspect for construction debris.
    - h. Clean furnace flue and inspect for construction debris.
    - i. Inspect operation of power vents.
    - j. Purge gas line.
    - k. Inspect and adjust vibration isolators and seismic restraints.
    - l. Verify bearing lubrication.
    - m. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
    - n. Adjust fan belts to proper alignment and tension.
    - o. Start unit.
    - p. Start refrigeration system when outdoor-air temperature is within normal operating limits.
    - q. Inspect and record performance of interlocks and protective devices including response to smoke detectors by fan controls and fire alarm.
    - r. Operate unit for run-in period.
    - s. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:

- 1) Measure gas pressure at manifold.
- 2) Measure combustion-air temperature at inlet to combustion chamber.
- 3) Measure flue-gas temperature at furnace discharge.
- 4) Perform flue-gas analysis. Measure and record flue-gas carbon dioxide and oxygen concentration.
- 5) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
- t. Calibrate thermostats.
- u. Adjust and inspect high-temperature limits.
- v. Inspect outdoor-air dampers for proper stroke and interlock with return-air dampers, **as directed**.
- w. Start refrigeration system and measure and record the following:
  - 1) Coil leaving-air, dry- and wet-bulb temperatures.
  - 2) Coil entering-air, dry- and wet-bulb temperatures.
  - 3) Outdoor-air, dry-bulb temperature.
  - 4) Outdoor-air-coil, discharge-air, dry-bulb temperature.
- x. Verify operational sequence of controls.
- y. Measure and record the following airflows. Plot fan volumes on fan curve.
  - 1) Supply-air volume.
  - 2) Return-air volume.
  - 3) Outdoor-air intake volume.
- z. Simulate maximum cooling demand and inspect the following:
  - 1) Compressor refrigerant suction and hot-gas pressures.
  - 2) Short circuiting of air through outside coil or from outside coil to outdoor-air intake.
- aa. Verify operation of remote panel including pilot-light operation and failure modes. Inspect the following:
  - 1) High-limit heat exchanger.
  - 2) Alarms.
3. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
4. Remove and replace components that do not pass tests and inspections and retest as specified above.
5. Prepare written report of the results of startup services.
- D. Adjusting
  1. Adjust initial temperature and humidity set points.
  2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project outside normal occupancy hours for this purpose.
- E. Demonstration
  1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain rooftop replacement-air units.

END OF SECTION 23 74 16 13



## SECTION 23 74 16 13a - SELF-CONTAINED AIR-CONDITIONERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for self-contained air-conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged air **OR** water-cooled air-conditioning units, **as directed**, with refrigerant compressors and controls, intended for indoor installations.

#### C. Submittals

1. Product Data: For each unit indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories.
2. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
4. Samples for Initial Selection: For units with factory-applied color finishes.
5. Operation and Maintenance Data: For self-contained air conditioners to include in emergency, operation, and maintenance manuals.
6. Warranty: Sample of special warranty.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency and marked for intended locations and application.
2. ARI Compliance:
  - a. Applicable requirements in ARI 210/240.
  - b. Applicable requirements in ARI 340/360.
  - c. Applicable requirements in ARI 390.
3. ASHRAE Compliance:
  - a. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
  - b. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of self-contained air conditioners that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period:
    - 1) For Compressor: One **OR** Five year(s), **as directed**, from date of Final Completion.
    - 2) For Parts: One **OR** Five year(s), **as directed**, from date of Final Completion.
    - 3) For Labor: One **OR** Five year(s), **as directed**, from date of Final Completion.

## 1.2 PRODUCTS

### A. Packaged Units

1. Description: Factory-assembled, wired, and tested, and fully charged with refrigerant and oil.
2. Configuration: Horizontal, ceiling-plenum mounted.
3. Configuration: Vertical, floor mounted; vertical and horizontal discharge.
4. Configuration: Horizontal, ceiling mounted and vertical, floor mounted; vertical and horizontal discharge.
5. Disconnect Switch: Factory mounted in control panel **OR** on equipment, **as directed**.

### B. Cabinet

1. Frame and Panels: Structural-steel frame with galvanized-steel panels and access doors or panels.
  - a. Exterior-Surface Finish: Factory painted in color selected by Architect.
  - b. Interior-Surface Finish: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Insulation: Minimum **1-inch- (25-mm-)**, thick, glass-fiber duct liner complying with ASTM C 1091 and having a microbial coating on cabinet interior and control panel. **1/2-inch- (13-mm-)** thick liner is acceptable for units smaller than **15 tons (50 kW)**.
3. Return-Air Opening: Rear, open **OR** flange for duct connection, **as directed**.
4. Corrosion-Resistant Treatment: Phenolic coating on unit interior and exterior.

### C. Supply-Air Fan

1. Fan Material: Galvanized steel.
2. Configuration: Double-width, double-inlet, forward-curved **OR** airfoil, **as directed**, centrifugal fan; statically and dynamically balanced. Vertical **OR** Horizontal discharge, **as directed**, with flexible discharge collar.
3. Drive: Belt, with fan mounted on permanently lubricated bearings **OR** Direct, with fan and motor resiliently mounted, **as directed**.
4. Fan Sheaves: Variable pitch, dynamically balanced, bored to fit shafts and keyed for initial startup.
5. Motor Sheave: Variable and adjustable pitch dynamically balanced, and selected to achieve specified rpm when set at midposition.
6. Belt Rating: As recommended by the manufacturer or a minimum of one and one-half times nameplate rating of motor.
7. Bearings: Grease lubricated with grease lines extended to exterior of unit with L-50 life at 200,000 hours.
8. Variable Air Volume: Variable-frequency motor controller with bypass.
9. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Special Motor Features: Premium efficiency, as defined in Division 23 Section "Common Motor Requirements For Hvac Equipment".
10. Isolation: Mount fan and motor on common subbase and mount assembly on spring isolators with minimum static deflection of **1 inch (25 mm)**.
11. Outdoor-Air-Intake Accessories:
  - a. Barometric Outdoor-Air Damper: Adjustable-blade damper allowing induction of up to 25 percent outdoor air when evaporator fan is running.
  - b. Motorized Outdoor-Air Damper: Motorized, two-position blade damper allowing induction of up to 25 percent outdoor air; with spring-return, low-voltage damper motor.
  - c. Energy-Recovery Ventilator: Assembly of desiccant-coated, heat-recovery wheels and centrifugal exhaust fans to transfer approximately 67 percent of the difference between the sensible and latent heat of outdoor and exhaust air.

- d. Air-Side Economizer: Damper assembly allowing induction of up to 100 percent outdoor air to maintain a selected mixed-air temperature; and exhaust damper and spring-return, low-voltage, modulating damper motor with minimum position adjustment.
- D. Refrigeration System
1. Compressor: Scroll type, hermetically sealed, 3600 rpm maximum, and resiliently mounted with positive lubrication and internal motor protection.
  2. Refrigerant Coils (Indoor and Outdoor for Air-Cooled Units): Seamless copper tubes expanded into aluminum fins.
    - a. Corrosion-Resistant Treatment: Phenolic coating applied with multiple dips and baked.
    - b. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve with adjustable superheat, filter dryer, sight glass, high-pressure relief valve, and charging valves.
    - c. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1 and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir.
    - d. Refrigerant: R-407C or R-410A.
    - e. Expansion valve with replaceable thermostatic element.
    - f. Refrigerant dryer.
    - g. High-pressure switch.
    - h. Low-pressure switch.
    - i. Thermostat for coil freeze-up protection during low ambient temperature operation or loss of air.
    - j. Low ambient temperature switch.
    - k. Brass service valves installed in discharge and liquid lines.
  3. Water-Cooled Condenser:
    - a. Description: Factory assembled and tested; tube in tube coaxial type with water-regulating valve.
    - b. Tubing: Nonferrous **OR** Copper **OR** Cupro-nickel, **as directed**, inner tube; steel with corrosion-resistant coating; refrigerant and water-side leak tested to **400 psig (2760 kPa)** underwater.
  4. Water-Side Economizer Section:
    - a. Description: Factory assembled and tested; consisting of water coil, modulating valves, controls, piping with cleanouts, and access panels.
    - b. Water Coil: Two **OR** Four rows, **as directed**, copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and copper **OR** cast-iron, **as directed** headers; leak tested to **300 psig (2070 kPa)** underwater; and having a two-position control valve.
- E. Heating Coil
1. Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**; leak tested to **300 psig (2070 kPa)** underwater; and having a two-position control valve.
  2. Electric Coil: Helical, nickel-chrome, resistance-wire heating elements with refractory ceramic support bushings; automatic-reset thermal cutout; built-in magnetic contactors; manual-reset thermal cutout; airflow-proving device; and one-time fuses in terminal box for overcurrent protection.
- F. Controls
1. Control Package: Factory wired, including contactor, high- and low-pressure cutouts, internal-winding thermostat for compressor, control-circuit transformer, and noncycling reset relay.
  2. Time-Delay Relay: Five-minute delay to prevent compressor cycling.
  3. Adjustable Thermostat: Unit mounted **OR** Remote, **as directed**, to control the following:
    - a. Supply fan.
    - b. Compressor.
    - c. Condenser.

- d. Hot-water coil valve.
- e. Electric heater.
- 4. System Selector Switch: Heat-off-cool **OR** Off-heat-auto-cool, **as directed**.
- 5. Fan Control Switch: Auto-on.
- 6. Time Clock, **as directed**: Cycle unit on and off.
- 7. Microprocessor Control Panel: Controls unit functions, including refrigeration and safety controls, and the following:
  - a. Supply fan.
  - b. Supply-fan motor speed.
  - c. Compressors.
  - d. Air-cooled condenser.
  - e. Cooling tower pump.
  - f. Modulating, hot-water coil valve.
  - g. Multistep, electric heater.
  - h. Time-of-day control to cycle unit on and off.
  - i. Night-heat, morning warm-up cycle.
  - j. Economizer control.
  - k. Panel-mounted control switch to operate unit in remote or local control mode, or to stop or reset.
  - l. Panel-mounted indication of the following:
    - 1) Operating status.
    - 2) System diagnostics and safety alarms.
    - 3) Supply-air temperature set point.
    - 4) Zone heating-temperature set point.
    - 5) Supply-air pressure set point.
    - 6) Economizer minimum position set point.
    - 7) Supply-air-pressure, high-limit set point.
    - 8) Monitor constant and variable motor loads.
    - 9) Monitor variable-frequency drive operation.
    - 10) Monitor economizer cycle.
    - 11) Monitor cooling load.
    - 12) Monitor air distribution static pressure and ventilation air volumes.
- G. Evaporator Coil
  - 1. Direct-Expansion Coil: Seamless copper tubes expanded into aluminum fins.
    - a. Corrosion-Resistant Treatment, **as directed**: Phenolic coating applied with multiple dips and baked.
  - 2. Refrigerant Circuits: A separate circuit for each compressor, with externally equalized thermal-expansion valve with adjustable superheat, **as directed**, filter-dryer, sight glass, high-pressure relief valve, **as directed**, and charging valves.
- H. Remote Air-Cooled Condenser
  - 1. Description: Factory assembled and tested; consisting of condenser coil, fans and motors, and operating controls; suitable for roof mounting.
    - a. Condenser Coil: Aluminum-fin copper tube with integral subcooler; leak tested to **450 psig (3110 kPa)**.
    - b. Condenser Fans: Direct-drive propeller type.
    - c. Fan Motors: Three-phase, permanently lubricated, ball-bearing motors with built-in thermal-overload protection. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - d. Refrigerant Line Kits: Annealed-copper suction and liquid lines that are factory cleaned, dried, pressurized, and sealed; insulated suction line; flared fittings at evaporator end, no fitting at condenser end; and service valves for both suction and liquid lines.
    - e. Terminate suction and liquid refrigerant piping with service valves within unit.
    - f. Low Ambient Control: Cycles fans to permit operation down to **45 deg F (7 deg C)**.

**OR**

Low Ambient Control: Cycles fans and modulates condenser fan damper assembly to permit operation down to **0 deg F (minus 18 deg C)**.

g. Coil Guard: Painted galvanized steel with louvered grilles.

h. Corrosion-Resistant Treatment: Phenolic coating applied in multiple dips and baked.

I. Integral Air-Cooled Condenser For Units **15 Tons (50 kW)** And Smaller

1. Description: Factory assembled and tested; consisting of condenser coil, fans and motors, and cabinet.

a. Condenser Coil: Aluminum-fin copper tube with integral subcooler; leak tested to **425 psig (2930 kPa)**.

b. Condenser Fan: Direct-drive propeller type with permanently lubricated motor with built-in thermal-overload protection.

c. Low Ambient Control: Cycles fans to permit operation down to **0 deg F (minus 18 deg C)**.

J. Air Filters

1. Permanent Filters: **1-inch- (25-mm-)** thick, cleanable panel filters.

**OR**

Disposable Filters: **1-inch- (25-mm-)** **OR** **2-inch- (50-mm-)**, **as directed**, thick, glass-fiber, flat **OR** pleated, **as directed**, panel filters.

**OR**

Extended-Surface, Disposable Panel Filters: **2-inch- (50-mm-)** **OR** **4-inch- (100-mm-)**, **as directed**, thick, dry, filters with fibrous media material formed into deep-V-shaped pleats and held by self-supporting wire grid holding frames, with nonflammable cardboard media and media-grid frame.

a. Efficiency: ASHRAE 52.2 MERV rating of 6 or higher.

2. Air-Pressure Switch (for units larger than 15 tons (50 kW)): Indicates dirty filters.

K. Accessories:

1. Manual outdoor-air damper.

2. Motorized outdoor-air damper.

3. Air-side economizer.

4. Water-side economizer.

5. Hot-gas bypass.

6. Air Pressure Switch: Indicates when differential pressure exceeds set point representing dirty filters.

L. Single-Point Electrical Characteristics:

1. Volts: **120 OR 208 OR 230 OR 460, as directed.**

2. Phase: Single **OR** Three, **as directed.**

3. Hertz: 60.

4. Full-Load Amperes: **as directed.**

5. Minimum Circuit Ampacity: **as directed.**

6. Maximum Overcurrent Protection: **as directed.**

1.3 EXECUTION

A. Installation

1. Install units level and plumb.

2. Anchor units to structure.

3. Install seismic restraints.

4. Install static-pressure probe (for units larger than 15 tons (50 kW) equipped with inlet vanes).



5. Install water-cooled units with thermometer and pressure gage at the water supply and return connection.
6. Install vibration spring isolators under base of unit, with minimum static deflection of **1 inch (25 mm)**. Refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

**B. Connections**

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  - a. Water Coil Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return coil with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
  - b. Water-Cooled Condenser Connections: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply and return with shutoff-duty valve and union or flange on the supply connection and with throttling-duty valve and union or flange on the return connection.
2. Where installing piping adjacent to equipment, allow space for service and maintenance of equipment.
3. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to self-contained air-conditioners with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".

**C. Field Quality Control**

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
2. Perform tests and inspections.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
3. Tests and Inspections:
  - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Units will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.

**D. Startup Service**

1. Engage a factory-authorized service representative to perform **OR** perform startup service, **as directed**.

**E. Demonstration**

1. Engage a factory-authorized service representative to train **OR train** the Owner's maintenance personnel, **as directed** to adjust, operate, and maintain units.

END OF SECTION 23 74 16 13a

## SECTION 23 74 16 13b - UNIT VENTILATORS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for unit ventilators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes unit ventilators and accessories with the following heating and cooling features:
  - a. Hydronic, Steam, and Electric heating coil.
  - b. Hydronic, Steam, and Electric reheat coil.
  - c. Hydronic and Direct-expansion refrigerant cooling coil.

#### C. Definitions

1. BAS: Building automation system.
2. HGBP: Hot-gas bypass.

#### D. Submittals

1. Product Data: Include rated capacities, operating characteristics, and furnished specialties and accessories for each unit type and configuration.
2. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - a. Plans, elevations, sections, and details.
  - b. Details of anchorages and attachments to structure and to supported equipment.
  - c. Wiring Diagrams: Power, signal, and control wiring.
4. Manufacturer Seismic Qualification Certification: Submit certification that unit ventilators, accessories, and components will withstand seismic forces defined in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.
3. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

#### F. Warranty





1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of condensing units that fail in materials or workmanship within specified warranty period.
  - a. Failures include, but are not limited to, the following:
    - 1) Compressor failure.
    - 2) Condenser coil leak.
  - b. Warranty Period: Four **OR** Five **OR** 10, **as directed**, years from date of Final Completion.
  - c. Warranty Period (Compressor Only): Five **OR** 10, **as directed**, years from date of Final Completion.
  - d. Warranty Period (Condenser Coil Only): Five years from date of Final Completion.

## 1.2 PRODUCTS

### A. Manufactured Units

1. Description: Factory-packaged and -tested units rated according to ARI 840, ASHRAE 33, and UL 1995, including finished cabinet, filter, cooling coil, drain pan, supply-air fan and motor in blow-through **OR** draw-through, **as directed**, configuration, and hydronic cooling coil.

### B. Cabinets

1. Insulation: Minimum **1/2-inch (13-mm) OR 1-inch (25-mm), as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
  - a. Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
  - b. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Drain Pans: Plastic **OR** Insulated galvanized steel with plastic liner, **as directed**, formed as required by ASHRAE 62.1. Drain pan shall be removable, **as directed**.
3. Cabinet Frame and Access Panels: Welded-steel frame with removable panels fastened with hex-head tamperproof fasteners and key-operated control and valve access doors, **as directed**.
  - a. Steel components exposed to moisture shall be hot-dip galvanized after fabrication.
4. Cabinet Finish: Baked-on primer ready for field painting.
5. Cabinet Finish: Baked enamel, in manufacturer's standard **OR** custom, **as directed**, paint color as selected by the Owner.
6. Indoor-Supply-Air Grille: Steel **OR** Aluminum, **as directed**, double deflection, adjustable **OR** adjustable linear bar, **as directed**.
7. Return-Air Inlet: Front toe space **OR** Back inlet with top inlet grille, **as directed**.
8. End Panels: Matching material and finish of unit ventilator.
9. Outdoor-Air Wall Box: Minimum **0.1265-inch- (3.2-mm-)** thick, aluminum, rain-resistant louver and box with integral eliminators and bird screen.
  - a. Louver Configuration: Horizontal **OR** Vertical, **as directed**, rain-resistant louver.
  - b. Louver Material: Aluminum **OR** Steel, **as directed**.
  - c. Bird Screen: **1/2-inch (13-mm)** mesh screen on interior side of louver.
  - d. Decorative Grille: On outside of intake.
  - e. Finish: Anodized aluminum **OR** Baked enamel, **as directed**, color as selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.

### C. Coils

1. Test and rate unit ventilator coils according to ASHRAE 33.
2. Hydronic Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **200 psig (1378 kPa)** and a maximum entering-water temperature of **220 deg F (104 deg C)**. Include manual air vent and drain valve.

3. Steam Coils: Copper distributing, **as directed**, tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, rated for a minimum working pressure of **75 psig (517 kPa)**.
  4. Electric-Resistance Heating Coils: Nickel-chromium heating wire or tubular elements in coil fins, free of expansion noise and hum, with fuses in terminal box for overcurrent protection, and continuous limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.
  5. Indoor Refrigerant Coils: Copper tube, with mechanically bonded aluminum fins spaced no closer than **0.1 inch (2.5 mm)**, and brazed joints at fittings. Comply with ARI 210/240, and leak test to minimum **450 psig (3105 kPa)** for a minimum **300-psig (2070-kPa)** working pressure. Include thermal expansion valve.
- D. Indoor Fan
1. Fan and Motor Board: Removable.
    - a. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or painted-steel wheels; and aluminum, painted-steel, or galvanized-steel fan scrolls.
    - b. Fan Shaft and Bearings: Hollow steel shaft with permanently lubricated, resiliently mounted bearings.
    - c. Motor: Permanently lubricated, multispeed, resiliently mounted on motor board. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - d. Wiring Termination: Connect motor to chassis wiring with plug connection.
- E. Dampers
1. Mixing Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric **OR** pneumatic, **as directed**, actuator.
  2. Outdoor-Air Dampers: Galvanized-steel blades with edge and end seals and nylon bearings; with electric **OR** pneumatic, **as directed**, actuator.
  3. Face and Bypass Dampers: Galvanized-steel damper blades with edge and end seals and nylon bearings; with factory-mounted electric **OR** pneumatic, **as directed**, actuator.
  4. Comply with ASHRAE/IESNA 90.1.
- F. Accessories
1. Exhaust Shutter: Barometric **OR** Motorized, modulating, **as directed**, type designed to limit room pressure to maximum **0.10-inch wg (25 kPa)** with steel **OR** aluminum **OR** fabric, **as directed**, damper blades including edge and end seals, in galvanized-steel frame with outdoor **OR** indoor **OR** outdoor and interior, **as directed**, wall grille.
  2. Subbase: Sheet metal floor-mounting base with leveling screws and black enamel finish.
  3. Insulated false back with gasket seals on wall and outdoor-air plenum.
    - a. Insulation: Minimum **1/2-inch (13-mm) OR 1-inch (25-mm)**, **as directed**, thick, coated glass fiber **OR** foil-covered, closed-cell foam **OR** matte-finish, closed-cell foam, **as directed**, complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916.
      - 1) Fire-Hazard Classification: Insulation and adhesive shall have a combined maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM E 84.
      - 2) Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  4. Return-air plenum, **6 inches (150 mm)** thick, designed to take return air from top inlet grilles in cabinets on both sides of unit ventilator with gasket seals on wall and outdoor-air plenum extension.
  5. Duct flanges for supply-, return-, and outdoor-air connections.
  6. Radiation Grille: Steel **OR** Aluminum, **as directed**, linear-bar **OR** stamped, **as directed**, grille with finish to match discharge-air grille.



7. Filters: Minimum arrestance according to ASHRAE 52.1, and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
  - a. Washable Foam: 70 percent arrestance and 3 MERV.  
**OR**  
Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.  
**OR**  
Pleated Cotton-Polyester Media: 90 percent arrestance and 7 MERV.
8. Energy Recovery Wheel:
  - a. Casing: Steel with manufacturer's standard paint coating and with the following:
    - 1) Integral purge section.
    - 2) Casing seals on periphery of rotor, on duct divider, and on purge section.
    - 3) Support rotor on grease-lubricated ball bearings with extended grease fittings. Mount horizontal wheels on tapered roller bearing.
  - b. Rotor: Corrugated-aluminum, segmented wheel strengthened with radial spokes, and having nontoxic, noncorrosive silica-gel desiccant coating. Construct media for passing maximum 800-micrometer solids and maximum 0.04 percent cross contamination by volume of exhaust air. Drive rotor with belt around outside of rotor.
  - c. Defrost Coils: Electric defrost coil in the exhaust airstream.
  - d. Drive: Fractional horsepower motor and gear reducer, with speed changed by adjustable variable frequency controller.
  - e. Inlet and Discharge Fans: Forward curved, centrifugal; resiliently mounted with flexible duct connections.
    - 1) Motor and Drive: Permanently lubricated, direct driven. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - f. Filters: **1-inch- (25-mm-)** thick, disposable type, mounted in galvanized-steel frame upstream of energy recovery wheel in both supply and exhaust airstreams.
  - g. Electrical: Single electrical connection from attached unit ventilator.
- G. Factory Hydronic Piping Package
  1. Piping: **ASTM B 88, Type L (ASTM B 88M, Type B) OR ASTM B 88, Type M (ASTM B 88M Type C), as directed**, copper tube with wrought-copper fittings and brazed joints. Label piping to indicate service, inlet, and outlet. Crossover piping, **NPS 1-1/2 (DN 40) OR NPS 2 (DN 50), as directed**, with shutoff valves.
  2. Control Valves: Electric **OR** Pneumatic, **as directed**, actuators compatible with terminal controller and building controls.
    - a. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for dual-temperature-water coil.
    - b. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for chilled-water coil.
    - c. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for hot-water heating coil.
    - d. Two **OR** Three, **as directed**, -way, two-position **OR** modulating, **as directed**, control valve for hot-water reheat coil.
  3. Hose Kits: Minimum **400-psig (2758-kPa)** working pressure, and operating temperatures from **33 to 211 deg F (0.5 to 99 deg C)**. Tag hose kits to equipment designations.
    - a. Length: **24 inches (600 mm) OR 36 inches (900 mm), as directed**.
    - b. Minimum Diameter: Equal to unit ventilator connection size.
  4. Isolation Valves, Strainers, Unions, and Balance Valves:
    - a. Two-Piece Ball Valves: Bronze body with stainless-steel ball and stem and galvanized-steel lever handle for each supply and return connection. If balancing device is combination shutoff type with memory stop, isolation valve may be omitted on the return.
    - b. Calibrated-Orifice Balancing Valves: Bronze body, ball type; **125-psig (860-kPa)** working pressure, **250 deg F (121 deg C)** maximum operating temperature; with calibrated orifice or venturi, connections for portable differential pressure meter with integral seals, threaded ends, and equipped with a memory stop to retain set position.

- c. Automatic Flow-Control Valve: Brass or ferrous-metal body; 300-psig (2070-kPa) working pressure at 250 deg F (121 deg C), with removable, corrosion-resistant, tamperproof, self-cleaning piston spring; factory set to maintain constant indicated flow with plus or minus 10 percent over differential pressure range of 2 to 80 psig (13.8 to 552 kPa).
  - d. Y-Pattern Hydronic Strainers: Cast-iron body (ASTM A 126, Class B); 125-psig (860-kPa) working pressure; with threaded connections, bolted cover, perforated stainless-steel basket, and bottom drain connection. Include minimum NPS 1/2 (DN 15) hose-end, full-port, ball-type blowdown valve in drain connection.
  - e. Wrought-Copper Unions: ASME B16.22.
- H. Remote Condensing Units
1. Description: Factory assembled and tested; consisting of compressors, condenser coils, fans, motors, refrigerant receiver, and operating controls. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
  2. Casing: Steel with baked-enamel finish; removable panels for access to controls, weep holes for water drainage, and mounting holes in base.
    - a. Casing Finish: Baked enamel, in manufacturer's standard OR custom, as directed, paint color as selected by the Owner.
  3. Compressor: Hermetic, scroll OR reciprocating, as directed, type; internally isolated for vibration with factory-installed safety devices as follows:
    - a. Antirecycle timer.
    - b. High-pressure cutout.
    - c. Low-pressure cutout or loss-of-charge switch.
    - d. Internal thermal-overload protection.
    - e. Current and voltage sensitive safety devices.
  4. Compressor Motor: Start capacitor, relay, and contactor. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  5. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
  6. Refrigerant Piping Materials:
    - a. Drawn-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B).
    - b. Annealed-Temper Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B) OR ASTM B 88, Type K (ASTM B 88M, Type A), as directed.
    - c. Wrought-Copper Fittings: ASME B16.22.
  7. Refrigerant: R-407C OR R-410A, as directed.
  8. Low ambient controls to permit operation down to 45 deg F (7 deg C).
  9. Crankcase heater.
  10. Charging and service fittings on exterior of casing.
  11. Filter dryer.
  12. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.
  13. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
  14. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
  15. Condenser Fan: Direct-drive, aluminum propeller fan; motor with thermal-overload protection.
    - a. Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  16. Accessories: Polyethylene mounting base to provide a permanent foundation.
- I. Integral Cooling Chassis
1. Description: Assembly mounted within unit ventilator, factory assembled and tested; consisting of compressors, condenser coils, fans, motors, and refrigerant receivers; removable for maintenance, with plug and receptacle connections for control and power wiring. Construct, test, and rate condensing units according to ARI 210/240 and ASHRAE 15.
  2. Casing: Galvanized steel with removable panels for access to controls and refrigerant piping.
  3. Exterior Louver: Extruded aluminum.

4. Compressor: Hermetic, scroll **OR** reciprocating, **as directed**, type; internally isolated for vibration with factory-installed safety devices as follows:
  - a. Antirecycle timer.
  - b. High-pressure cutout.
  - c. Low-pressure cutout or loss-of-charge switch.
  - d. Internal thermal-overload protection.
  - e. Current- and voltage-sensitive safety devices.
5. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1, "Energy Standard for Buildings except Low-Rise Residential Buildings."
6. Refrigerant Piping Materials:
  - a. Drawn-Temper Copper Tube: **ASTM B 88, Type L (ASTM B 88M, Type B).**
  - b. Annealed-Temper Copper Tube: **ASTM B 88, Type L (ASTM B 88M, Type B) OR ASTM B 88, Type K (ASTM B 88M, Type A), as directed.**
  - c. Wrought-Copper Fittings: ASME B16.22.
7. Refrigerant: R-407C **OR** R-410A, **as directed**.
8. Low ambient controls to permit operation down to **45 deg F (7 deg C).**
9. Crankcase heater.
10. Charging and service fittings.
11. Filter dryer.
12. Air-to-Air Heat Pump: Pilot-operated, sliding-type reversing valve with replaceable magnetic coil, and controls for air-to-air heat pump operation with supplemental heat.
13. HGBP, constant-pressure expansion valve and controls to maintain continuous refrigeration system operation at 10 percent of full load.
14. Condenser: Copper-tube, aluminum-fin coil, with liquid subcooler.
15. Direct-Driven Condenser Fan: Forward curved, double width, centrifugal; thermoplastic or painted-steel wheels and galvanized-steel fan scrolls.
  - a. Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".

J. Basic Unit Controls

1. Control devices and operational sequences are specified in Division 23 Section(s) "Instrumentation And Control For Hvac" AND "Sequence Of Operations For Hvac Controls".  
**OR**  
Basic Unit Controls:
  - a. Control voltage transformer.
  - b. Wall-mounting **OR** Unit-mounted, **as directed**, thermostat with the following features.
    - 1) Heat-cool-off switch.
    - 2) Fan on-auto switch.
    - 3) Fan-speed switch.
    - 4) Manual **OR** Automatic, **as directed**, changeover.
    - 5) Adjustable deadband.
    - 6) Concealed **OR** Exposed, **as directed**, set point.
    - 7) Concealed **OR** Exposed, **as directed**, indication.
    - 8) Degree F **OR** Degree C, **as directed**, indication.
  - c. Wall-mounting **OR** Unit-mounted, **as directed**, humidistat.
    - 1) Concealed **OR** Exposed, **as directed**, set point.
    - 2) Concealed **OR** Exposed, **as directed**, indication.
  - d. Wall-mounting **OR** Unit-mounted, **as directed**, temperature sensor.
  - e. Unoccupied-period-override push button.
  - f. Data entry and access port.
    - 1) Input data includes room temperature and humidity set points, and occupied and unoccupied periods.
    - 2) Output data includes room temperature and humidity, supply-air temperature, entering-water temperature, operating mode, and status.
2. DDC, **as directed**, Terminal Controller:



- a. Safety Controls Operation: Freezestat shall stop fan and close outdoor-air damper if air less than **38 deg F (3 deg C)** enters coils.
- b. Scheduled Operation: Occupied and unoccupied periods on seven-day clock with a minimum of four programmable periods per day.
- c. Unoccupied Period Override Operation: Two, **as directed**, hours.
- d. Dual-Temperature Coil Operation:
  - 1) Occupied Periods: When chilled water is available, open **OR** modulate, **as directed**, control valve if room temperature exceeds thermostat set point. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat set point.
  - 2) Unoccupied Periods: When chilled water is available, close control valve. When hot water is available, open **OR** modulate, **as directed**, control valve if room temperature falls below thermostat setback temperature.
- e. Hydronic Cooling-Coil Operation:
  - 1) Occupied Periods: Open **OR** Modulate, **as directed**, control valve to provide cooling if room temperature exceeds thermostat set point.
  - 2) Unoccupied Periods: Close control valve.
- f. Refrigerant-Coil Operation:
  - 1) Occupied Periods: Start compressor to maintain room temperature.
  - 2) Unoccupied Periods: Stop compressor cooling **OR** Cycle compressor for heating to maintain setback temperature, **as directed**.
- g. Supplemental, **as directed**, Heating-Coil Operation:
  - 1) Occupied Periods: Open control valve **OR** Modulate control valve **OR** Energize electric-resistance coil, **as directed**, to provide heating if room temperature falls below thermostat set point.
  - 2) Unoccupied Periods: Start fan and open control valve **OR** modulate control valve **OR** energize electric-resistance coil, **as directed**, if room temperature falls below setback temperature.
  - 3) Switch refrigerant-reversing valve to operate supplemental coil for heating when outdoor temperature is below **25 deg F (4 deg C)**.
- h. Reheat-Coil Operation:
  - 1) Humidity Control for Occupied Periods: Humidistat opens control valve **OR** modulates control valve **OR** energizes electric-resistance coil, **as directed**, to provide heating. As room temperature rises above the set point, cooling coil valve opens **OR** modulates, **as directed**, to maintain room temperature.
  - 2) Humidity Control for Unoccupied Periods: Close control valve **OR** De-energize, **as directed**.
- i. Outdoor-Air Damper Operation: Open to 25 percent fixed minimum intake during occupied periods, and close during unoccupied periods.
- j. Outdoor-Air Damper Operation: Open to 25 percent fixed minimum intake, and maximum 100 percent of the fan capacity to comply with ASHRAE Cycle II during occupied periods, and close during unoccupied periods. Microprocessor controller shall permit air-side economizer operation when outdoor air is less than **60 deg F (15 deg C)**.
- k. Carbon Dioxide Sensor Operation: During occupied periods, reset minimum outdoor-air ratio down to minimum 10 percent to maintain maximum 800-ppm concentration.
- l. Face-and-Bypass Damper Operation: Position damper to face of coils until room temperature equals thermostat set point; bypass after room-temperature set point is achieved.
- m. Cooling Lockout: During economizer cycle operation, block out cooling.
- n. HGBP: Open HGBP solenoid valve to maintain minimum suction pressure at compressor.
- o. Energy Recovery Wheel Operation:
  - 1) Factory-mounted and -wired, starting relay and manual motor starter for field wiring.
  - 2) Occupied period is established by remote signal **OR** room occupancy sensor, **as directed**.
  - 3) Energy recovery wheel and inlet and discharge fans operate during occupied periods after room temperature set point has been achieved.

- 4) Energy recovery wheel operates during occupied periods, but stops when unit ventilator controls call for cooling, and outdoor-air temperatures permit free air cooling.
- 5) Energy recovery wheel and fans stop during unoccupied periods.
- p. Controller shall have volatile-memory backup.
3. BAS Interface Requirements:
  - a. Interface relay for scheduled operation.
  - b. Interface relay to provide indication of fault at the central workstation.
  - c. Provide BACnet **OR** LonWorks, **as directed**, interface for central BAS workstation for the following functions:
    - 1) Adjust set points.
    - 2) Unit ventilator start, stop, and operating status.
    - 3) Data inquiry to include outdoor-air damper position, **as directed**, supply- and room-air temperature and humidity, **as directed**.
    - 4) Occupied and unoccupied schedules.
4. Electrical Connection: Factory wire motors and controls for a single electrical connection.

#### K. Metal Shelves And Cabinets

1. Include manufacturer's standard cabinets to match unit ventilators with required installation hardware as indicated:
  - a. Open Shelving with Reinforced Shelves:
    - 1) Return-air plenum **OR** Radiation enclosure, **as directed**, and aluminum bar grille with finish to match unit ventilator grille.
    - 2) Through-piping enclosure with solid top.
  - b. Closed Shelving with Reinforced Shelves:
    - 1) Return-air plenum **OR** Radiation enclosure, **as directed**, and aluminum bar grille with finish to match unit ventilator grille.
    - 2) Through-piping enclosure with solid top.
    - 3) Two sliding doors with key-operated locks.
  - c. Utility compartment with access panel with key-operated lock.
  - d. Wall and corner filler sections, and end panels finished to match shelving.
2. Painted Finish: Manufacturer's standard **OR** custom, **as directed**, baked enamel, in color selected by the Owner, applied to shelving before shipping.
3. Cabinet Top: Plastic-laminate top in color and pattern selected by the Owner from manufacturer's standard **OR** custom, **as directed**, colors.

### 1.3 EXECUTION

#### A. Installation

1. Install unit ventilators to comply with NFPA 90A.
2. Suspend horizontal unit ventilators from structure with threaded steel rods and minimum **0.25-inch (6.35-mm)** static-deflection, elastomeric vibration isolation hanger **OR 1.0-inch (25-mm)** static-deflection spring hangers, **as directed**. Vibration isolators are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
3. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Install devices **48 inches (1220 mm) OR 60 inches (1525 mm)**, **as directed**, above finished floor.
4. Refer to Division 23 Section "Packaged Compressor And Condenser Units" for condensing units matched to refrigerant cooling coil packaged in unit ventilators.

#### B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties. Specific connection requirements are as follows:
  - a. Install piping adjacent to machine to allow service and maintenance.



- b. Connect piping to unit ventilator factory hydronic piping package. Install piping package if shipped loose.
    - c. Connect condensate drain to indirect waste.
  2. Install refrigerant piping as required by Division 23 Section "Refrigerant Piping", and add refrigerant as required to compensate for length of piping.
  3. Connect supply and return ducts to unit ventilators with flexible duct connectors specified in Division 23 Section "Air Duct Accessories". Comply with safety requirements in UL 1995 for duct connections.
  4. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  5. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
  1. Perform the following field tests and inspections and prepare test reports:
    - a. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
    - b. Operate electric heating elements through each stage to verify proper operation and electrical connections.
    - c. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
    - d. Record temperatures entering and leaving energy recovery wheel when outdoor-air temperature is a minimum of 15 deg F (8.3 deg C) higher, or 20 deg F (11 deg C) lower, than room temperature.
  2. Remove and replace malfunctioning units and retest as specified above.
- D. Adjusting
  1. Adjust initial temperature and humidity set points.
  2. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.
- E. Demonstration
  1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain unit ventilators.

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Task	Specification	Specification Description
23 74 16 13	07 72 13 00	Packaged, Outdoor, Central-Station Air-Handling Units

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## SECTION 23 74 23 13 - DIRECT-FIRED, MAKEUP AIR UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for direct-fired H&V units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes direct-fired H&V units with an evaporative cooling package, **as directed**.

#### C. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. LEED Submittal:
  - a. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings:
  - a. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
  - b. Wiring Diagrams: Power, signal, and control wiring.
4. Operation and maintenance data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.
3. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
4. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

### 1.2 PRODUCTS

#### A. Packaged Units

1. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, **as directed**, evaporative cooling package, **as directed**, and direct-fired gas furnace to be installed outside **OR** inside, **as directed**, the building.

#### B. Cabinet

1. Cabinet: Single-wall **OR** Double-wall, **as directed**, galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Cabinet shall be fully weatherized for outside installation, **as directed**.
2. Access Panels: Lift-out **OR** Piano hinged with cam-lock fasteners, **as directed**, for furnace and fan motor assemblies on both sides of unit.
3. Internal Insulation: Fibrous-glass duct lining, comply with ASTM C 1071, Type II, applied on complete unit **OR** furnace and fan sections only, **as directed**.
  - a. Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed.**
  - b. Insulation Adhesive: Comply with ASTM C 916, Type I.



- c. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
  4. Finish: Heat-resistant, baked enamel.
  5. Discharge: Horizontal **OR** Vertical, **as directed**, -pattern, galvanized-steel assembly with diffusers incorporating individually adjustable vanes.
  6. Roof Curb: Full-perimeter curb of sheet metal, minimum **16 inches (400 mm)** high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
  7. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
- C. Supply-Air Fan
1. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings **OR** pillow-block bearings rated for L50 or 200,000 hours with external grease fittings, **as directed**.
  2. Motor: Open dripproof **OR** Totally enclosed, **as directed**, single **OR** two, **as directed**, -speed motor.
  3. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
  4. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained, **as directed**, elastomeric **OR** spring, **as directed**, isolators.
- D. Outdoor-Air Intake
1. Outdoor-Air Hood: Galvanized steel with rain baffles, bird screen complying with ASHRAE 62.1, **as directed**, and finish to match cabinet; and sized to supply maximum 100 percent outdoor air.
- E. Air Filters
1. Comply with NFPA 90A.
  2. Cleanable Filters: **1-inch- (25-mm-) OR 2-inch-0 (50-mm-), as directed**, thick, cleanable metal mesh.
  3. Disposable Panel Filters: **1-inch- (25-mm-) OR 2-inch- (50-mm-), as directed**, thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1, **as directed**.
    - a. Media: Interlaced glass **OR** polyester, **as directed**, fibers.
    - b. Frame: Galvanized steel.
- F. Dampers
1. Outdoor-Air and Return-Air, **as directed**, Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of **10 cfm/sq. ft. (51 L/s per sq. m)** of damper area, at differential pressure of **2-inch wg (448 Pa)**.
  2. Fan-Discharge Dampers: Galvanized-steel, opposed-blade damper.
  3. Balancing/Bypass Dampers: Galvanized-steel, opposed-blade damper.
  4. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.
- G. Direct-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; and complying with ANSI Z83.4, "Direct Gas-Fired Make-Up Air Heaters"; ANSI Z83.18, "Direct Gas-Fired Industrial Air Heaters"; and NFPA 54, "National Fuel Gas Code."
  2. Inside Unit External Housing: Steel cabinet with integral support inserts.
  3. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts.
    - a. External Casing and Cabinet Finish: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface in color to match fan section.
  4. Burners: Cast-iron burner with stainless-steel mixing plates.

- a. Control Valve: Single stage **OR** Two stage **OR** Modulating with minimum turndown ratio of 25:1 or as otherwise directed, **as directed**.
  - b. Fuel: Natural **OR** Propane, **as directed**, gas.
  - c. Pilot: Electrically ignited by hot-surface ceramic igniter.
5. Safety Controls:
  - a. Gas Manifold: Safety switches and controls to comply with ANSI standards **OR** FMG **OR** IRI, **as directed**.
  - b. Purge-Period Timer: Automatically delays burner ignition and bypasses low-limit control.
  - c. Airflow Proving Switch: Dual pressure switch senses correct airflow before energizing pilot and requires airflow to be maintained within minimum and maximum pressure settings across burner.
  - d. Manual-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
  - e. Gas Train: Redundant, automatic main gas valves, electric pilot valve, hydraulic **OR** electronic, **as directed**, modulating temperature control valve, main and pilot gas regulators, main and pilot manual shutoff valves, main and pilot pressure taps, and high-low gas pressure switches, **as directed**, to comply with IRI requirements **OR** to comply with FMG requirements, **as directed**.
  - f. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
  - g. Control Transformer: Integrally mounted 24-V ac.
- H. Evaporative Cooling Package
  1. Cabinet: Single-wall **OR** Double-wall, **as directed**, galvanized- or aluminized-steel panels lined with ABS polymer, **as directed**, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs and having a stainless-steel reservoir with overflow and drain with full-port, brass-fitted ball valve. Cabinet shall be fully weatherized for outside installation, **as directed**.
    - a. External Casing and Cabinet Finish: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface in color to match fan section.
  2. Media: UL 900, Class 2, **6-inch- (150-mm-) OR 8-inch- (200-mm-) OR 12-inch- (300-mm-)**, **as directed**, thick cellulose **OR** glass-fiber, **as directed**, media with rigidizing agents, fungicides, and wetting agents. Minimum 90 percent contact factor.
    - a. Moisture elimination pad.
  3. Water-Circulation System: Submersible centrifugal sump pump with inlet strainer, brass balancing valve located in pump discharge, and thermally protected motor; water distribution troughs or piping at top of media pads; and float-operated, makeup water and bleed-off valves.
    - a. Automatic Fill and Drain Kit: Water supply and drain, solenoid valves for initial sump fill and for draining sump.
  4. Water-Saver System: Timer, solenoid valve, and water distribution piping to apply the water supply to the media.
  5. Comply with applicable requirements in ASHRAE 62.1.
- I. Controls
  1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
  2. Control Panel: Surface-mounted **OR** Recessed, with trim ring, **as directed**, remote panel, with engraved plastic cover, and the following lights and switches:
    - a. On-off **OR** On-off-auto, **as directed**, switch.
    - b. Summer-winter **OR** Heat-off-cool, **as directed**, switch. Automatic changeover, **as directed**.
    - c. Supply-fan operation indicating light.
    - d. Heating operation indicating light.
    - e. Damper position potentiometer.
    - f. Thermostat.
    - g. Cooling operation indicating light.





- h. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
- i. Safety-lockout indicating light.
- 3. Refer to Division 23 Section "Instrumentation And Control For Hvac" for control equipment and sequence of operation.
- 4. Control Devices:
  - a. Remote Thermostat: Adjustable room thermostat with temperature readout.
  - b. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
  - c. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
  - d. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than **75 deg F (24 deg C)** above normal maximum operating temperature.
  - e. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.  
**OR**  
 Timers: Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.
  - f. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.
  - g. Fan-Speed Controllers: Solid-state model providing field-adjustable proportional control of motor speed. Equip with filtered circuit to eliminate radio interference.
- 5. Fan Control: Interlock fan to start with exhaust fan(s). See Division 23 Section(s) "Axial Hvac Fans" OR "Centrifugal Hvac Fans" OR "Hvac Power Ventilators" OR "Sequence Of Operations For Hvac Controls", **as directed**, for exhaust fan controls.  
**OR**  
 Fan Control: Timer starts and stops direct-fired H&V unit and exhaust fan(s).
  - a. Fan-Discharge Thermostat: Stops fan when discharge-air temperature is less than **40 deg F (4 deg C)**.
  - b. Smoke detectors, located in supply and return, **as directed**, air, shall stop fans when the presence of smoke is detected.
  - c. Controls two **OR** variable, **as directed**, -speed motor controller using speed switch on control panel **OR** variable-speed potentiometer on control panel **OR** static-pressure transmitter, **as directed**.
- 6. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.  
**OR**  
 Outdoor-Air and Fan-Discharge Damper Control, 100 Percent Outdoor-Air Units:
  - a. Outdoor-air damper shall open when supply fan starts, and close when fan stops.
  - b. Fan-discharge dampers shall operate to vary the amount of outdoor air to match exhaust-fan operation.**OR**  
 Outdoor-Air and Balancing/Bypass Damper Control, Variable Outdoor-Air Units:
  - a. Outdoor-air damper shall open when supply fan starts, and close when fan stops.
  - b. Balancing/bypass dampers shall modulate to maintain minimum air velocity through burner.**OR**  
 Outdoor-Air, Balancing/Bypass, and Return-Air Damper Control:
  - a. Outdoor-air damper shall open when supply fan starts, and close when fan stops.

- b. Return-air dampers shall modulate in response to potentiometer on control panel **OR** building pressure control, **as directed**.
      - c. Balancing/bypass dampers shall modulate to maintain minimum air velocity through the burner.
    - 7. Temperature Control: Operates gas valve to maintain supply-air or room temperature.
      - a. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in fan outlet.  
**OR**  
Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment, **as directed**, and unit-mounted control adjustment **OR** and adjustment on remote control panel, **as directed**.
      - b. Timer shall select remote setback thermostat to maintain space temperature at **50 deg F (10 deg C)**.
    - 8. Evaporative Cooling Controls:
      - a. Start and stop water-circulation-system sump pump to maintain space temperature.
      - b. Automatic Fill Control: A switch in the unit control panel shall close sump drain valve and open makeup water valve.
      - c. Automatic Drain Control: Opens sump drain valve and closes makeup water valve from a switch in the unit control panel **OR** when an outside thermostat senses **40 deg F (4 deg C)** or less, **as directed**.
      - d. Water-Saver System: Remote thermostat shall open water-supply valve to maintain dry-bulb temperature in space. Timer shall activate thermostat circuit.
    - 9. DDC: Stand-alone control module for link between unit controls and DDC system. Control module shall be compatible with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
      - a. Provide start and stop interface relay, and relay to notify DDC system alarm condition.
      - b. Provide hardware interface or additional sensors as follows:
        - 1) Room temperature.
        - 2) Discharge-air temperature.
        - 3) Furnace operating.
  - J. Motors
    - 1. Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
- 1.3 EXECUTION
- A. Installation
    - 1. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
    - 2. Install roof curb on roof structure, according to ARI Guideline B **OR** NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts", **as directed**. Install and secure direct-fired H&V units on curbs, and coordinate roof penetrations and flashing with roof construction.  
**OR**  
Install restrained vibration isolation roof-curb rails on roof structure according to ARI Guideline B **OR** NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts", **as directed**. Install and secure direct-fired H&V units on rails, and coordinate roof penetrations and flashing with roof construction. Restrained isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
    - 3. Install suspended units from spring hangers with minimum **1-inch (25-mm)** static deflection; refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".  
**OR**



Install floor-mounted units on restrained, **as directed**, spring isolators with minimum **1-inch (25-mm)** static deflection; refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

4. Install controls and equipment shipped by manufacturer for field installation with direct-fired H&V units.

#### B. Connections

1. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.
  - a. Gas Piping: Comply with requirements in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.
  - b. Makeup Water: Comply with requirements in Division 22 Section "Domestic Water Piping" for valves and accessories on piping connections to evaporative cooling units.
  - c. Drain: Comply with requirements in Division 22 Section "Sanitary Waste And Vent Piping" for traps and accessories on piping connections to evaporative cooling units.
2. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to direct-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".
3. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
4. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### C. Startup Service

1. Complete installation and startup checks according to manufacturer's written instructions and perform the following:
  - a. Inspect for visible damage to furnace combustion chamber.
  - b. Inspect casing insulation for integrity, moisture content, and adhesion.
  - c. Verify that clearances have been provided for servicing.
  - d. Verify that controls are connected and operable.
  - e. Verify that filters are installed.
  - f. Purge gas line.
  - g. Inspect and adjust vibration isolators and seismic restraints, **as directed**.
  - h. Verify bearing lubrication.
  - i. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
  - j. Adjust fan belts to proper alignment and tension.
  - k. Start unit according to manufacturer's written instructions.
  - l. Complete startup sheets and attach copy with Contractor's startup report.
  - m. Inspect and record performance of interlocks and protective devices; verify sequences.
  - n. Operate unit for run-in period recommended by manufacturer.
  - o. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
    - 1) Measure gas pressure on manifold.
    - 2) Measure combustion-air temperature at inlet to combustion chamber.
    - 3) Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
  - p. Calibrate thermostats.
  - q. Adjust and inspect high-temperature limits.
  - r. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
  - s. Start evaporative cooler system and measure and record the following:
    - 1) Leaving-air, dry- and wet-bulb temperatures.
    - 2) Entering-air, dry- and wet-bulb temperatures.

- t. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
  - u. Measure and record airflow. Plot fan volumes on fan curve.
  - v. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
    - 1) High-limit heat.
    - 2) Alarms.
  - w. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
- 2. Remove and replace malfunctioning components that do not pass tests and inspections and retest as specified above.
  - 3. Prepare written report of the results of startup services.
- D. Adjusting
- 1. Adjust initial temperature set points.
  - 2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  - 3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Demonstration
- 1. Train Owner's maintenance personnel to adjust, operate, and maintain direct-fired H&V units.

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## SECTION 23 74 23 13a - INDIRECT-FIRED, PACKAGED H&V UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for indirect-fired, H&V units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes indirect-fired H&V units with the following accessories:
  - a. Gas or Oil furnace.
  - b. Evaporative cooling package.

#### C. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. Shop Drawings:
  - a. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
  - b. Mounting Details: For securing and flashing roof curb to roof structure. Indicate coordinating requirements with roof membrane system.
  - c. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
  - d. Wiring Diagrams: Power, signal, and control wiring.
3. Operation and maintenance data.
4. Warranty: Special warranty specified in this Section.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

#### E. Warranty

1. Manufacturer's standard form in which manufacturer agrees to replace heat exchangers of indirect-fired H&V units that fail in materials or workmanship within five years **OR** 10 years, **as directed**, from date of Final Completion.

### 1.2 PRODUCTS

#### A. Packaged Units

1. Factory-assembled, prewired, self-contained unit consisting of cabinet, supply fan, controls, filters, evaporative cooling package, **as directed**, and indirect-fired gas **OR** oil, **as directed**, furnace to be installed outside **OR** inside, **as directed**, the building.

#### B. Cabinet

1. Cabinet: Single-wall **OR** Double-wall, **as directed**, galvanized-steel panels, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs. Cabinet shall be fully weatherized for outside installation, **as directed**.
2. Access Panels: Lift-out **OR** Piano hinged with cam-lock fasteners, **as directed**, for furnace and fan motor assemblies on both sides of unit.



3. Internal Insulation: Fibrous-glass duct lining, comply with ASTM C 1071, Type II, applied on complete unit for outside unit or furnace and fan sections only for inside unit.
    - a. Thickness: **1 inch (25 mm) OR 2 inches (50 mm), as directed.**
    - b. Insulation Adhesive: Comply with ASTM C 916, Type I.
    - c. Mechanical Fasteners: Galvanized steel suitable for adhesive attachment, mechanical attachment, or welding attachment to casing without damaging liner when applied as recommended by manufacturer and without causing air leakage.
  4. Finish: Heat-resistant, baked enamel.
  5. Discharge: Horizontal-pattern **OR** Vertical-pattern, **as directed**, galvanized-steel assembly with diffusers incorporating individually adjustable vanes.
  6. Roof Curb: Full-perimeter curb of sheet metal, minimum **16 inches (400 mm)**, unless directed otherwise, high, with wood nailer, neoprene sealing strip, and welded Z-bar flashing.
- C. Supply-Air Fan
1. Fan Type: Centrifugal, rated according to AMCA 210; statically and dynamically balanced, galvanized steel; mounted on solid-steel shaft with heavy-duty, self-aligning, permanently lubricated ball bearings **OR** pillow-block bearings rated for L50 or 200,000 hours with external grease fittings, **as directed.**
  2. Motor: Open dripproof **OR** Totally enclosed, **as directed**, single-speed motor.
  3. Drive: V-belt drive with matching fan pulley and adjustable motor sheaves and belt assembly.
  4. Mounting: Fan wheel, motor, and drives shall be mounted in fan casing with restrained (for seismic areas), elastomeric **OR** spring, **as directed**, isolators.
- D. Outdoor-Air Intake
1. Outdoor-Air Hood: Galvanized steel with rain baffles, bird screen, and finish to match cabinet; and sized to supply maximum 30 percent **OR** 100 percent, **as directed**, outdoor air.
- E. Air Filters
1. Comply with NFPA 90A.
  2. Cleanable Filters: **1-inch- (25-mm-) OR 2-inch- (50-mm-), as directed**, thick, cleanable metal mesh.
  3. Disposable Panel Filters: **1-inch- (25-mm-) OR 2-inch- (50-mm-), as directed**, thick, factory-fabricated, flat-panel-type, disposable air filters with holding frames, with a minimum efficiency report value of 6 according to ASHRAE 52.2 and 90 percent average arrestance according to ASHRAE 52.1.
    - a. Media: Interlaced glass **OR** polyester, **as directed**, fibers.
    - b. Frame: Galvanized steel.
- F. Dampers
1. Outdoor-Air and Return-Air, **as directed**, Damper: Galvanized-steel, opposed-blade dampers with vinyl blade seals and stainless-steel jamb seals, having a maximum leakage of **10 cfm/sq. ft. (51 L/s per sq. m)** of damper area, at differential pressure of **2-inch wg (448 Pa)**.
  2. Damper Operator: Direct coupled, electronic with spring return or fully modulating as required by the control sequence.
- G. Indirect-Fired Gas Furnace
1. Description: Factory assembled, piped, and wired; and complying with ANSI Z21.47, "Gas-Fired Central Furnaces," and NFPA 54, "National Fuel Gas Code."
    - a. AGA Approval: Designed and certified by and bearing label of AGA.
    - b. Burners: Aluminized steel with stainless-steel inserts **OR** Stainless steel, **as directed.**
      - 1) Gas Control Valve: Single stage **OR** Two stage **OR** Modulating, **as directed.**
      - 2) Fuel: Natural **OR** Propane, **as directed**, gas.
      - 3) Minimum Thermal Efficiency: 80 percent.
      - 4) Ignition: Electronically controlled electric spark with flame sensor.
      - 5) High-Altitude Model **OR** Kit, **as directed**: For Project elevation above sea level.



2. Venting: Gravity vented.
  3. Power Vent: Integral, motorized centrifugal fan interlocked with gas valve.
  4. Combustion-Air Intake: Separate combustion-air intake and vent terminal assembly.
  5. Inside Unit External Housing: Steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.
  6. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.
    - a. External Casing and Cabinet Finish: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface in color to match fan section.
  7. Internal Casing: Aluminized steel, arranged to contain airflow, with duct flanges at inlet and outlet.
  8. Heat Exchanger: Aluminized **OR** Stainless steel, **as directed**.
  9. Heat-Exchanger Drain Pan: Stainless steel.
  10. Safety Controls:
    - a. Vent Flow Verification: Differential pressure switch to verify open vent **OR** Flame rollout switch, **as directed**.
    - b. Control Transformer: 24-V ac.
    - c. High Limit: Thermal switch or fuse to stop burner.
    - d. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, hydraulic-modulating **OR** electronic-modulating, **as directed**, temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
    - e. Purge-period timer shall automatically delay burner ignition and bypass low-limit control.
    - f. Gas Manifold: Safety switches and controls to comply with ANSI standards and FMG **OR** IRI, **as directed**.
    - g. Airflow Proving Switch: Differential pressure switch senses correct airflow before energizing pilot.
    - h. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
    - i. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
- H. Oil-Fired Furnace
1. Description: Factory assembled, piped, and wired; and complying with UL 727, "Oil-Fired Central Furnaces."
  2. Inside Unit External Housing: Steel cabinet with integral support inserts and removable bottom arranged to serve as a drain pan.
  3. Outside Unit External Housing: Weatherproof steel cabinet with integral support inserts and removable bottom arranged to serve as drain pan.
    - a. External Casing and Cabinet Finish: Baked enamel **OR** Powder coating, **as directed**, over corrosion-resistant-treated surface in color to match fan section.
  4. Internal Casing: Aluminized steel, arranged to contain airflow, with duct flanges at inlet and outlet.
  5. Heat Exchanger: Welded, stainless steel, unless directed otherwise, with flame observation port, carbon dioxide sample port, and access panels for clean-out and service.
  6. Burners: Flame-retention, pressure-atomizing, forced-draft, gun type; with integral fuel pump and electronic spark ignition.
    - a. Fuel: No. 2, unless directed otherwise, fuel oil.
    - b. Minimum Thermal Efficiency: 80 percent **OR** 81 percent, **as directed**.
    - c. Ignition: Electronically controlled electric spark with flame sensor.
  7. Safety Controls:
    - a. Factory piped and wired to electrical junction box mounted on unit.
    - b. Oil-pressure switch.
    - c. Control Transformer: Integrally mounted 24-V ac.
    - d. Cad-cell safety system.
    - e. Manual reset flame safety.
  8. Accessories:



- a. Factory mounted and wired to electrical junction box on unit.
- b. Oil Booster Pump: **30-gph (108-L/h) OR 70-gph (252-L/h)**, **as directed**, capacity; motor and 2-stage fuel unit with pressure-regulating valve and strainer.
- c. Oil-pressure relief valve.
- d. Outdoor Combustion-Air Adapter: Sealed to housing and fitted with quick access cover, or door and fitting for terminating outdoor-air duct.

I. Evaporative Cooling Package

- 1. Cabinet: Single-wall **OR** Double-wall, **as directed**, galvanized- or aluminized-steel panels lined with ABS polymer, as required, formed to ensure rigidity and supported by galvanized-steel channels or structural channel supports with lifting lugs and having a stainless-steel reservoir with overflow and drain with full-port, brass-fitted ball valve. Cabinet shall be fully weatherized for outside installation, **as directed**.
  - a. External Casing and Cabinet Finish: Baked enamel, **unless directed otherwise to be** Powder coating, over corrosion-resistant-treated surface in color to match fan section.
- 2. Media: UL 900, Class 2, **6-inch- (150-mm-) OR 8-inch- (200-mm-) OR 12-inch- (300-mm-)**, **as directed**, thick cellulose **OR** glass-fiber, **as directed**, media with rigidizing agents, fungicides, and wetting agents. Minimum 90 percent contact factor.
  - a. Moisture elimination pad.
- 3. Water-Circulation System: Submersible centrifugal sump pump with inlet strainer, brass balancing valve located in pump discharge, and thermally protected motor; water distribution troughs or piping at top of media pads; and float-operated, makeup water and bleed-off valves.
  - a. Automatic Fill and Drain Kit: Water supply and drain, solenoid valves for initial sump fill and for draining sump.
- 4. Water-Saver System: Timer, solenoid valve, and water distribution piping to apply the water supply to the media.

J. Controls

- 1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
- 2. Control Panel: Surface-mounted **OR** Recessed, **as directed**, with trim ring, remote panel, with engraved plastic cover, and the following lights and switches:
  - a. On-off **OR** On-off-auto, **as directed**, fan switch.
  - b. Summer-winter **OR** Heat-off-cool, **as directed**, switch. Automatic changeover, **as directed**.
  - c. Supply-fan operation indicating light.
  - d. Heating operation indicating light.
  - e. Damper position potentiometer.
  - f. Thermostat.
  - g. Cooling operation indicating light.
  - h. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
  - i. Safety-lockout indicating light.
- 3. Control Devices:
  - a. Remote Thermostat: Adjustable room thermostat with temperature readout.
  - b. Remote Setback Thermostat: Adjustable room thermostat without temperature readout.
  - c. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.
  - d. Fire-Protection Thermostats: Fixed or adjustable settings to operate at not less than **75 deg F (24 deg C)** above normal maximum operating temperature.
  - e. Timers: Seven-day, programming-switch timer with synchronous-timing motor and seven-day dial; continuously charged, nickel-cadmium-battery-driven, eight-hour, power-failure carryover; multiple-switch trippers; minimum of two and maximum of eight signals per day with two normally open and two normally closed output contacts.

**OR**

- Timers: Solid-state, programmable time control with 4 separate programs; 24-hour battery carryover; individual on-off-auto switches for each program; 365-day calendar with 20 programmable holidays; choice of fail-safe operation for each program; and system fault alarm.
- f. Ionization-Type Smoke Detectors: 24-V dc, nominal; self-restoring; plug-in arrangement; integral visual-indicating light; sensitivity that can be tested and adjusted in place after installation; integral addressable module; remote controllability; responsive to both visible and invisible products of combustion; self-compensating for changes in environmental conditions.
  4. Fan Control: Interlock fan to start with exhaust fan(s). See Division 23 Section(s) "Axial Hvac Fans" OR "Centrifugal Hvac Fans" OR "Hvac Power Ventilators" OR "Sequence Of Operations For Hvac Controls", **as directed**, for exhaust fan controls.
  5. Fan Control: Timer starts and stops direct-fired H&V unit and exhaust fan(s).
    - a. Fan-Discharge Thermostat (for units with evaporative cooling package): Stops fan when discharge-air temperature is less than **40 deg F (4 deg C)**.
    - b. Smoke detectors, located in supply and return, **as directed**, air, shall stop fans when the presence of smoke is detected.
  6. Outdoor-Air Damper Control, 100 Percent Outdoor-Air Units: Outdoor-air damper shall open when supply fan starts, and close when fan stops.
  7. Mixed Outdoor- and Return-Air Damper Control: When fan is running, outdoor- and return-air dampers shall modulate to supply minimum outdoor air as follows:
    - a. Minimum 30 percent outdoor air.
    - b. Outdoor-air quantity adjusted by potentiometer on control panel.
    - c. Outdoor-air quantity to maintain minimum building static pressure.
  8. Temperature Control: Operates gas valve to maintain supply-air temperature.
    - a. Operates gas valve to maintain discharge-air temperature with factory-mounted sensor in blower outlet.
    - b. Operates gas valve to maintain space temperature with wall-mounting, field-wired sensor with temperature adjustment, **as directed**, and unit-mounted control adjustment, **OR** and adjustment on remote-control panel, **as directed**.
    - c. Timer shall select remote setback thermostat to maintain space temperature at **50 deg F (10 deg C)**.
    - d. Furnace Control: Two or four steps of control using one or two furnace sections in series. **OR**  
Furnace Control: 20 to 100 percent modulation of the firing rate. 10 to 100 percent with dual furnace units.
  9. Evaporative Cooling Controls:
    - a. Start and stop water-circulation-system sump pump to maintain space temperature.
    - b. Automatic Fill Control: A switch in the unit control panel shall close sump drain valve and open makeup water valve.
    - c. Automatic Drain Control: Opens sump drain valve and closes makeup water valve from a switch in the unit control panel **OR** when an outside thermostat senses **40 deg F (4 deg C)** or less, **as directed**.
    - d. Water-Saver System: Remote thermostat shall open water-supply valve to maintain dry-bulb temperature in space. Timer shall activate thermostat circuit.
  10. DDC: Stand-alone control module for link between unit controls and DDC system. Control module shall be compatible with temperature-control system specified in Division 23 Section "Instrumentation And Control For Hvac".
    - a. Provide start and stop interface relay, and relay to notify DDC system alarm condition.
    - b. Provide hardware interface or additional sensors as follows:
      - 1) Room temperature.
      - 2) Discharge-air temperature.
      - 3) Furnace operating.

K. Motors



1. Comply with requirements are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".

### 1.3 EXECUTION

#### A. Installation

1. Install gas-fired units according to NFPA 54, "National Fuel Gas Code."
2. Install oil-fired duct heaters and associated fuel and vent piping according to NFPA 31 and applicable local codes and regulations.
3. Install roof curb on roof structure, according to ARI Guideline B **OR** NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts," **as directed**. Install and secure direct-fired H&V units on curbs, and coordinate roof penetrations and flashing with roof construction.  
**OR**  
Install restrained vibration isolation roof-curb rails on roof structure according to ARI Guideline B **OR** NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts," **as directed**. Install and secure indirect-fired H&V units on rails, and coordinate roof penetrations and flashing with roof construction. Restrained isolation roof-curb rails are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
4. Install suspended units from spring hangers with minimum 1-inch (25-mm) static deflection; refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. Install floor-mounted units on restrained, **as directed**, spring isolators with minimum 1-inch (25-mm) static deflection; refer to Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. Install controls and equipment shipped by manufacturer for field installation with indirect-fired H&V units.
7. Piping Connections: Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to machine to allow service and maintenance.
  - a. Gas Piping: Comply with requirements in Division 23 Section(s) "Facility Natural-gas Piping" **OR** "Facility Liquefied-petroleum Gas Piping", **as directed**. Connect gas piping with shutoff valve and union and with sufficient clearance for burner removal and service. Provide AGA-approved flexible connectors.
  - b. Fuel Oil Piping: Comply with requirements in Division 23 Section "Facility Fuel-oil Piping". Connect to fuel oil supply and return piping with shutoff valve and union at each connection.
  - c. Makeup Water: Comply with requirements in Division 22 Section "Domestic Water Piping" for valves and accessories on piping connections to evaporative cooling units.
  - d. Drain: Comply with requirements in Division 22 Section "Sanitary Waste And Vent Piping" for traps and accessories on piping connections to evaporative cooling units.
8. Duct Connections: Duct installation requirements are specified in Division 23 Section "Metal Ducts". Drawings indicate the general arrangement of ducts. Connect supply and return, **as directed**, ducts to indirect-fired H&V units with flexible duct connectors. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories".
9. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
10. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

END OF SECTION 23 74 23 13a

## SECTION 23 76 13 00 - DEHUMIDIFICATION UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for mechanical dehumidification units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes packaged, factory-assembled and -tested, refrigerant-type, mechanical dehumidification units designed for outdoor and indoor installation.

#### C. Performance Requirements

1. Seismic Performance: Dehumidification units shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### D. Submittals

1. Product Data: For each dehumidification unit indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5, "Systems and Equipment."
3. Shop Drawings: For each dehumidification unit indicated. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
4. Delegated-Design Submittal: For dehumidification units indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include adjustable motor bases, rails, and frames for equipment mounting.
  - b. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Seismic Qualification Certificates: For accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Source quality-control reports.
7. Field quality-control reports.
8. Operation and Maintenance Data: For dehumidification units to include in emergency, operation, and maintenance manuals.
9. Warranty: Sample of special warranty.



## E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
  - a. Applicable requirements in ASHRAE 62.1, Section 5, "Systems and Equipment" and Section 7, "Construction and Startup."
  - b. Applicable requirements in ASHRAE 15, "Safety Standard for Refrigeration Systems."
3. ASHRAE/IESNA 90.1 Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6, "Heating, Ventilating, and Air-Conditioning."

## F. Coordination

1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
2. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

## G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of dehumidification units that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Compressors: Manufacturer's standard, but not less than two **OR** five, **as directed**, years from date of Final Completion.
  - b. Warranty Period for Refrigerant Coils: Manufacturer's standard, but not less than five years from date of Final Completion.

## 1.2 PRODUCTS

## A. Casings

1. Casing: Single-wall **OR** Double-wall, **as directed**, construction with corrosion-protective coating and exterior baked-enamel **OR** powder-coated, **as directed**, finish, stainless-steel fasteners, knockouts for electrical and piping connections, condensate drain connection, and lifting lugs.
  - a. Access: Removable panels **OR** Hinged access doors, **as directed**, with neoprene gaskets.
  - b. Insulation: Minimum **1/2-inch- (13-mm-)** thick thermal insulation **OR 2-inch- (50-mm-)** thick, glass-fiber-insulation fill with no metal structure through the insulation, **as directed**.
  - c. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
2. Drain Pan and Connection: Plastic **OR** Stainless steel, **as directed**; insulated and complying with ASHRAE 62.1, **as directed**.

## B. Fans

1. Supply Fans: Forward curved **OR** Backward inclined, **as directed**, centrifugal; galvanized steel with baked-enamel **OR** powder-coated, **as directed**, finish; belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing of dehumidification unit.
2. Exhaust **OR** Return, **as directed**, Fans: Forward curved **OR** Backward inclined, **as directed**, centrifugal; galvanized steel with baked-enamel **OR** powder-coated, **as directed**, finish; belt driven with adjustable sheaves and self-aligning, grease-lubricated ball bearings with extended grease fittings easily accessible inside the casing of dehumidification unit.
3. Fan Motor: Comply with requirements in Division 23 Section "Common Motor Requirements For Hvac Equipment".
  - a. Enclosure Type: Totally enclosed, fan cooled.

## C. Filters

1. Glass Fiber: Minimum 80 percent arrestance according to ASHRAE 52.1, and MERV 5 according to ASHRAE 52.2.



2. Pleated: Minimum 90 percent arrestance according to ASHRAE 52.1, and MERV 7 according to ASHRAE 52.2.
- D. Refrigeration System
1. Energy Efficiency: Equal to or greater than prescribed by ASHRAE/IESNA 90.1.
  2. Refrigerant Coils: Copper tubes with mechanically bonded aluminum fins; factory fabricated and tested to comply with ASHRAE 33 and ARI 410; with multiple refrigerant circuits, seamless-copper headers with brazed connections, and galvanized **OR** stainless, **as directed**, -steel frame. Coil and fins shall have a polyester coating. Coils shall have a minimum **300-psig (2070-kPa)** working-pressure rating and be factory tested to **450 psig (3105 kPa)** and to **300 psig (2070 kPa)** while underwater.
  3. Compressors: Hermetic, scroll compressors with integral vibration isolators and crankcase heaters that de-energize during compressor operation; with thermal-expansion valves, filter-driers, sight glasses, compressor service valves, and liquid- and suction-line service valves.
    - a. Number of Refrigerant Circuits: Two for compressor capacities more than **7-1/2 tons (26.4 kW)**.
    - b. Refrigerant: R-134a **OR** R-407C **OR** R-410A, **as directed**.
    - c. Capacity Control:
      - 1) Hot-gas bypass valve and piping on one compressor.
      - 2) Cycle compressor.
    - d. Low-Pressure Cutout: Manual reset after three automatic-reset failures.
    - e. High-Pressure Cutout: Manual reset.
    - f. Compressor Motor Overload Protection: Manual reset.
    - g. Antirecycling Timing Device: Prevent compressor restart for five minutes after shutdown.
    - h. Defrost Cycle (for ice rinks): Adjustable timer shuts off supply fan. Compressor cycles until suction line temperature confirms thawed evaporator coil. Timer limits defrost time to 10 minutes.
  4. Energy Recovery Heat Exchanger (Pool Heater): Cupronickel, coaxial, vented, double-wall construction for potable-water service.
- E. Remote-Mounted, Air-Cooled Condenser Unit
1. Casing: Steel, finished with baked enamel; with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gage ports on exterior of casing.
  2. Refrigerant Coil: ARI 210/240, copper tube with mechanically bonded aluminum fins; with liquid subcooler.
  3. Fan: Aluminum-propeller type, directly connected to permanently lubricated motor with integral thermal-overload protection.
  4. Adjustable, Low Ambient Head-Pressure Control: Designed to operate at temperatures as low as **0 deg F (minus 18 deg C)** by cycling condenser fans and controlling speed of last fan of each circuit.
  5. Mounting Base: Polyethylene.
- F. Heating Coils
1. Hot-Water Coil: Continuous circuit coil fabricated according to ARI 410.
    - a. Tubes: Copper.
    - b. Fins: Aluminum **OR** Copper, **as directed**, with fin spacing **0.125 inch (3.18 mm) OR 0.091 inch (2.31 mm) OR 0.071 inch (1.80 mm) OR 0.067 inch (1.70 mm) OR 0.056 inch (1.42 mm) OR 0.0075 inch (0.19 mm), as directed**.
    - c. Fin and Tube Joints: Mechanical bond.
    - d. Headers: Cast iron with drain and air vent tappings.
    - e. Frames: Galvanized-steel channel, **0.052 inch (1.3 mm)**.
    - f. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
      - 1) Working-Pressure Ratings: **200 psig (1380 kPa), 325 deg F (163 deg C)**.
    - g. Source Quality Control: Test to **300 psig (2070 kPa)**.



2. Steam Coil: Distribution header coil fabricated according to ARI 410, with threaded steam supply and condensate connections.
  - a. Tubes: Copper.
  - b. Fins: Aluminum **OR** Copper, **as directed**, with fin spacing **0.125 inch (3.18 mm) OR 0.091 inch (2.31 mm) OR 0.071 inch (1.80 mm) OR 0.067 inch (1.70 mm) OR 0.056 inch (1.42 mm) OR 0.0075 inch (0.19 mm), as directed.**
  - c. Fin and Tube Joints: Mechanical bond.
  - d. Headers: Cast iron with drain and air vent tapings.
  - e. Frames: Galvanized-steel channel, **0.052 inch (1.3 mm).**
  - f. Ratings: Design tested and rated according to ASHRAE 33 and ARI 410.
    - 1) Working-Pressure Ratings: **100 psig (690 kPa), 400 deg F (205 deg C).**
  - g. Source Quality Control: Test to **200 psig (1380 kPa).**
3. Electric-Resistance Heating Coil: Comply with UL 1995.
  - a. Heating Element: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium oxide powder in tubular-steel sheath; with spiral-wound, copper-plated steel fins continuously brazed to sheath.  
**OR**  
Heating Element: Open-coil resistance wire of 80 percent nickel and 20 percent chromium; supported and insulated by floating ceramic bushings recessed into casing openings; fastened to supporting brackets and mounted in galvanized-steel frame.
  - b. Overtemperature Protection: Disk-type, automatic-reset, thermal-cutout safety device; serviceable through terminal box without removing heater from unit.
  - c. Thermal Cutouts: Load carrying, manual reset or replaceable, and factory wired in series with each heater stage.
  - d. Control: Disconnecting means, overcurrent protection, and airflow proving switch.

#### G. Dampers

1. Outdoor-Air Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rod rotating in sintered bronze or nylon bearings. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod. Size for 0 to 25 percent outdoor air, with manual **OR** motorized, **as directed**, operator and filter.
2. Face-and-Bypass Dampers: Opposed-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in sintered bronze or nylon bearings with operating rods connected with a common linkage. Provide blade gaskets and edge seals, and mechanically fasten blades to operating rod.
3. Outdoor- and Return-Air **OR** Outdoor-, Return-, and Exhaust-Air, **as directed**, Dampers: Parallel-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers mechanically fastened to steel **OR** cadmium-plated steel, **as directed**, operating rod in reinforced cabinet. Connect operating rods with common linkage and interconnect linkages so dampers operate simultaneously.
4. Outdoor- and Return-Air **OR** Outdoor-, Return-, and Exhaust-Air, **as directed**, Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade **OR** parallel-blade, **as directed**, arrangement with steel **OR** cadmium-plated steel, **as directed**, operating rods rotating in stainless-steel sleeve **OR** sintered bronze or nylon, **as directed**, bearings mounted in a single galvanized-steel **OR** aluminum **OR** extruded-aluminum, **as directed**, frame, and with operating rods connected with a common linkage. Leakage rate shall not exceed **5 cfm/sq. ft. (0.22 L/s per sq. m) at 1-inch wg (250 Pa) and 9 cfm/sq. ft. (0.4 L/s per sq. m) at 4-inch wg (1.0 MPa).**
5. Damper Operator: **115 OR 24, as directed**, -V ac, close coupled, with gear train sealed in oil and with spring return.

#### H. Controls

1. Comply with requirements in Division 23 Section "Instrumentation And Control For Hvac" for control equipment and in Division 23 Section "Sequence Of Operations For Hvac Controls".
2. Control Panel: Integral service compartment containing fan-motor thermal and overload cutouts, compressor thermal and overload cutouts, 115-V control transformer if required, magnetic contactors for fan and compressor motors, and a nonfused factory-mounted and -wired disconnect switch for single external electrical power connection.
3. Building Automation System Interface: Factory-installed hardware and software to enable the building automation system to monitor, control, and display status and alarms.
4. Operating Control: Space humidistat cycles the compressor. Humidistat shall incorporate fan on-off-auto switch.
5. Operating Controls (for indoor pool units with typical manufacturer's control panel): Factory-installed microprocessor controller, capable of being remotely mounted.
  - a. Display the following on the face of controller:
    - 1) System on.
    - 2) System dehumidifying mode.
    - 3) System air-conditioning mode.
    - 4) System outdoor-air (economizer) mode.
    - 5) System heating pool water.
    - 6) Auxiliary space heat is operating.
    - 7) Unit requires service.
    - 8) Return-air (space) temperature.
    - 9) Return-air (space) humidity.
    - 10) Pool-water temperature.
    - 11) Outdoor-air temperature.
  - b. Indicate the following sensor failures on panel:
    - 1) Airflow: Dirty air filter, blocked airflow, and fan failure.
    - 2) Refrigerant high and low pressure.
    - 3) High water temperature.
    - 4) High and low evaporator temperature.
    - 5) Low water flow.
    - 6) Communication fault.
    - 7) System off.
    - 8) Antishort cycle delay.
    - 9) Power failure.
  - c. Provide access to the following set points on panel:
    - 1) Space temperature.
    - 2) Space relative humidity.
    - 3) Outdoor ventilation/air-conditioning changeover temperature.
    - 4) Airflow alarm.
  - d. Provide the following displays on panel:
    - 1) Space temperature.
    - 2) Space relative humidity.
    - 3) Outdoor-air temperature.
    - 4) Supply-air temperature.
    - 5) Return-air temperature.
    - 6) Airflow rating.
    - 7) Air-off evaporator temperature.
    - 8) Return-air relative humidity.
    - 9) Service codes.
  - e. Provide the following controls on panel:
    - 1) System on-off, fan continues to run.
    - 2) Fan on-off.
    - 3) Service code access.
    - 4) System dehumidifying mode.
    - 5) System air-conditioning mode.
    - 6) System outdoor-air (economizer) mode.



- 7) Auxiliary space heat is operating.
- 8) Outdoor-air-temperature, conditioned-space-temperature, and control set-point-temperature digital display.
- 9) Outdoor enthalpy digital display.
- 10) Filter pressure drop digital display.
- 11) Status: Airflow, fans, system, unit operation, and operating mode.
- 12) Alarm digital display.
6. Operating Controls: Factory-installed microprocessor controller.
  - a. Factory-installed operator panel with backlit display, capable of being remotely mounted, allows menu-driven display for navigation and control of unit.
  - b. Integral clock.
  - c. Personal computer interface.
  - d. Integral local area network for direct connection to BACnet **OR** LonWorks **OR** MODBUS, **as directed**.
  - e. Factory programmed.
  - f. Unit-Mounted Sensors:
    - 1) Airflow switch.
    - 2) Compressor-discharge temperature.
    - 3) Evaporator-air temperature.
    - 4) Pool-water-out temperature.
    - 5) Pool-water-in temperature.
    - 6) Relative humidity.
    - 7) Return-air temperature.
    - 8) Supply-air temperature.
  - g. Integral diagnostics.
  - h. Nonvolatile memory.
  - i. IP or SI display.
  - j. Provide the following status and alarm functions:
    - 1) System: On-off.
    - 2) Power failure.
    - 3) Fan: Off, overload.
    - 4) Compressor: On, turned off, overload, high pressure, low pressure, overheat, oil failure, and pumpdown.
    - 5) Evaporator damper closed.
    - 6) Pool: Low water flow, heating on.
    - 7) Dehumidification: Call for, on.
    - 8) Air Conditioning: Call for, on.
    - 9) System outdoor-air (economizer) mode.
    - 10) Auxiliary space heat on.
    - 11) Alarms: Firestat, freezestat, and filters.
  - k. Provide the following controls via operator panel:
    - 1) Compressor auto-off.
    - 2) Fan auto-off.
    - 3) Set-Point Adjustments: Relative humidity, temperatures, deadbands, and differentials.
    - 4) Sensor calibration.
  - l. Monitor constant and variable motor loads.
  - m. Monitor cooling load.
  - n. Monitor economizer cycles.
  - o. Monitor ventilation air volumes.
- I. Accessories
  1. Water-Cooling Heat Exchanger: Coaxial, vented, double-wall construction; with three-way refrigerant control valve.
  2. Smoke Detectors: Photoelectric detector located in return-air plenum, to de-energize unit.

- a. Operating Voltage: 24-V dc, nominal.
- b. Self-Restoring: Detectors do not require resetting or readjusting after actuation to restore them to normal operation.
- c. Plug-in Arrangement: Detector and associated electronic components mounted in module with tamper-resistant connection to fixed base with twist-locking plug. Terminals in fixed base accept building wiring.
- d. Integral Visual-Indicating Light: Digital-display type indicating detector operation.
- e. Sensitivity: Can be tested and adjusted in-place after installation.
- f. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to the fire-alarm control panel.
- g. Sensor: Digital display or infrared light source with matching silicon-cell receiver.
- h. Detector Sensitivity: Between **2.5 and 3.5 percent/foot** (**0.008 and 0.011 percent/mm**) of smoke obscuration when tested according to UL 268A.
- i. Integral Thermal Detector: Fixed-temperature type with **135 deg F** (**57 deg C**) setting.
3. Electrical Convenience Outlet: 115-V ac fused, duplex, straight-blade receptacles, separately fused and located inside casing of dehumidification unit or in roof-curb perimeter.

J. Roof Curbs

1. Roof curbs with vibration isolators and wind or seismic restraints are specified in Division 15 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
2. Materials: Galvanized steel with corrosion-protection coating, watertight gaskets, and factory-installed wood nailer; complying with NRCA standards.
3. Curb Insulation and Adhesive: Comply with NFPA 90A or NFPA 90B.
  - a. Materials: ASTM C 1071, Type I or II.
  - b. Thickness: **1 inch** (**25 mm**) **OR 1-1/2 inches** (**38 mm**) **OR 2 inches** (**50 mm**), **as directed**.
  - c. Application: Factory applied with adhesive and mechanical fasteners to the internal surface of curb.
  - d. Liner Adhesive: Comply with ASTM C 916, Type I.
  - e. Mechanical Fasteners: Galvanized steel, suitable for adhesive attachment, mechanical attachment, or welding attachment to duct without damaging liner when applied as recommended by manufacturer and without causing leakage in cabinet.
  - f. Liner materials applied in this location shall have airstream surface coated with a temperature-resistant coating or faced with a plain or coated fibrous mat or fabric, depending on service-air velocity.
4. Curb Height: **14 inches** (**355 mm**) **OR 24 inches** (**610 mm**) **OR 36 inches** (**910 mm**), **as directed**.
5. Wind and Seismic Restraints: Metal brackets compatible with the curb and casing, painted to match dehumidification unit; used to anchor unit to the curb and designed for loads at Project site. Comply with requirements in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment" for wind-load requirements.

K. Source Quality Control

1. Verification of Performance: Factory test and rate dehumidification units according to ARI 910.
2. Sound-Power-Level Ratings: Factory test and rate dehumidification units according to ARI 575.

1.3 EXECUTION

A. Examination

1. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
2. Examine roughing-in for hot-water **OR** steam **OR** refrigerant, **as directed**, piping systems to verify actual locations of piping connections before equipment installation.
3. Examine walls, floors, and roofs for suitable conditions where dehumidification units will be installed.
4. Proceed with installation only after unsatisfactory conditions have been corrected.

**B. Installation**

1. Equipment Mounting (for indoor or outdoor equipment supported on slabs-on-grade without vibration isolation devices): Install dehumidification units on concrete base(s). Comply with requirements for concrete base(s) specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
2. Equipment Mounting (for indoor or outdoor equipment supported on concrete equipment base with vibration isolation devices): Install dehumidification units on concrete base(s) using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for concrete base(s) specified in Division 03 Section "Cast-in-place Concrete". Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1 inch (25 mm), as directed**.
  - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base, and anchor into structural concrete floor.
  - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting (for installation of indoor or outdoor equipment on vibration isolation devices without concrete base): Install dehumidification units using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1 inch (25 mm), as directed**.
4. Equipment Mounting (for installation of indoor or outdoor equipment on vibration isolation equipment base): Install dehumidification units on vibration isolation equipment base. Comply with requirements specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
5. For installation of indoor or outdoor equipment without vibration isolation devices, with seismic restraints, and without concrete base: Install dehumidification units with **<Insert seismic-restraint device>**. Comply with requirements for seismic-restraint devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
6. For indoor units suspended from structure: Install continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of size required to support weight of dehumidification unit.
  - a. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Fabricate brackets or supports as required.
  - b. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
7. Curb Support (if curbs are furnished with dehumidification units for rooftop installations): Install roof curb on roof structure, level and secure, according to NRCA's "The NRCA Roofing and Waterproofing Manual, Fifth Edition." Install and secure dehumidification units on curbs, and coordinate roof penetrations and flashing with roof construction. Secure units to curb support with anchor bolts.
8. Unit Support: Install dehumidification units level on structural curbs **OR** pilings, **as directed**. Coordinate wall penetrations and flashing with wall construction. Secure units to structural support with anchor bolts.

9. Isolation Curb Support (for units mounted on isolation curbs): Install dehumidification units on isolation curbs, and install flexible duct connectors and vibration isolation and seismic-control devices. Flexible duct connectors are specified in Division 23 Section "Air Duct Accessories". Vibration isolation and seismic-control devices are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
- C. Connections
1. Where piping is installed adjacent to dehumidification units, allow space for service and maintenance of dehumidification units.
  2. Connect piping to dehumidification units mounted on vibration isolators with flexible connectors.
  3. Connect condensate drain pans using minimum **NPS 1-1/4 (DN 32)** copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan, and install cleanout at changes in direction.
  4. Refrigerant Piping: Comply with requirements in Division 23 Section "Refrigerant Piping". Connect to supply and return coil tapplings with shutoff valve and union or flange at each connection.
  5. Hot-Water Piping: Comply with requirements in Division 23 Section "Hydronic Piping". Connect to supply coil tapplings with shutoff valve, return coil tapplings with balancing valve, and union or flange at each connection.
  6. Steam and Condensate Piping: Comply with requirements in Division 23 Section "Steam And Condensate Heating Piping". Connect with shutoff valve and union or flange.
  7. Duct installation requirements are specified in other Division 21. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
    - a. Install ducts to termination in roof-mounted frames. Where indicated, terminate return-air duct through roof structure and insulate the space between roof and bottom of dehumidification unit.
- D. Field Quality Control
1. Perform tests and inspections.
  2. Tests and Inspections:
    - a. Leak Test: After installation, fill water coils with water, and test coils and connections for leaks. Repair leaks and retest until no leaks exist.
    - b. Charge refrigerant coils with refrigerant and test for leaks. Repair leaks and retest until no leaks exist.
    - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  3. Dehumidification unit will be considered defective if it does not pass tests and inspections.
  4. Prepare test and inspection reports.
- E. Startup Service
1. Perform startup service.
    - a. Complete installation and startup checks according to manufacturer's written instructions.
  2. Perform the following final checks before startup:
    - a. Verify that shipping, blocking, and bracing are removed.
    - b. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
    - c. Perform cleaning and adjusting specified in this Section.
    - d. Disconnect fan drive from motor, verify proper motor rotation direction, and verify free fan wheel rotation and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
    - e. Check lubrication of bearings, pulleys, belts, and other moving parts.
    - f. Set outside- and return-air mixing dampers to minimum outside-air setting.
    - g. Install clean filters.
    - h. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.

3. Starting procedures for dehumidification units include the following:
  - a. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm. Replace malfunctioning motors, bearings, and fan wheels.
  - b. Measure and record motor's electrical values for voltage and amperage.
  - c. Manually operate dampers from fully closed to fully open position and record fan performance.
4. Comply with requirements in Division 23 Section "Testing, Adjusting, And Balancing For Hvac" for testing, adjusting, and balancing of dehumidification unit.
5. Startup Report: Report findings during startup. Identify startup steps, corrective measures taken, and final results.

F. Adjusting

1. Adjust damper linkages for proper damper operation.
2. Adjust initial temperature and humidity set points.

G. Cleaning

1. Clean dehumidification units internally, on completion of installation, according to manufacturer's written instructions. Clean fan interiors to remove foreign material and construction dirt and dust. Vacuum clean fan wheels, cabinets, and coils' entering-air face.
2. After completing system installation, testing, and startup service of dehumidification units, clean filter housings and install new filters.

H. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain dehumidification units.

END OF SECTION 23 76 13 00





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Task	Specification	Specification Description
23 76 13 00	23 74 23 13	Direct-Fired, Makeup Air Units
23 76 13 00	23 74 23 13a	Indirect-Fired, Packaged H&V Units

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## SECTION 23 81 13 11 - PACKAGED TERMINAL AIR CONDITIONERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for packaged terminal air conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes packaged terminal air conditioners and their accessories and controls, in the following configurations:
  - a. Through-the-wall and freestanding air conditioners.
  - b. Cooling-only units.
  - c. Heat-pump units.
  - d. Cooling units with electric heat.
  - e. Cooling units with hydronic heat.
  - f. Cooling units with indirect-fired gas heat.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For packaged terminal air conditioners. Include plans, elevations, sections, details for wall penetrations, seismic bracing, **as directed**, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
4. Color Samples: For unit cabinet, discharge grille, and exterior louver, and for each color and texture specified.
5. Field quality-control reports.
6. Operation and maintenance data.
7. Warranty: Sample of special warranty.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of packaged terminal air conditioners that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Sealed Refrigeration System: Manufacturer's standard, but not less than five years from date of Final Completion, including components and labor.
  - b. Warranty Period for Nonsealed System Parts: Manufacturer's standard, but not less than five years from date of Final Completion, including only components and excluding labor.



- c. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Final Completion.

## 1.2 PRODUCTS

### A. Manufactured Units

1. Description: Factory-assembled and -tested, self-contained, packaged terminal air conditioner with room cabinet, electric refrigeration system, heating, **as directed**, and temperature controls; fully charged with refrigerant and filled with oil; with cord-connected **OR** hardwired, **as directed**, chassis.

### B. Chassis

1. Cabinet: **0.052-inch- (1.32-mm-)** thick steel with removable front panel with concealed latches.
  - a. Mounting: Wall with wall sleeve **OR** Floor with subbase, **as directed**.
  - b. Discharge Grille: Punched-louver discharge grille allowing four-way discharge-air pattern **OR** Extruded-aluminum discharge grille **OR** Reversible polycarbonate discharge grille allowing upward and horizontal airflow, **as directed**.
  - c. Louvers: Extruded aluminum with enamel finish **OR** Stamped aluminum with clear-anodized finish **OR** Stamped steel with enamel finish, **as directed**; white **OR** bronze **OR** brown **OR** beige, **as directed**, color.
  - d. Finish: Epoxy coating **OR** Baked enamel, **as directed**.
  - e. Access Door: Hinged door in top of cabinet for access to controls.
  - f. Cabinet Extension: Matching cabinet in construction and finish, allowing diversion of airflow to adjoining room; with grille.
  - g. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  - h. Subbase: Enameled steel with adjustable leveling feet and adjustable end plates, with factory-installed and -wired, fused disconnect switch and receptacle sized for unit, **as directed**.
  - i. Wall Sleeves: Galvanized steel with polyester finish **OR** Molded polymer **OR** Molded fiberglass-reinforced polyester, **as directed**.
2. Refrigeration System: Direct-expansion indoor coil with capillary restrictor; and hermetically sealed scroll compressor with vibration isolation and overload protection.
  - a. Indoor and Outdoor Coils: Seamless copper tubes mechanically expanded into aluminum fins with capillary tube distributor on indoor coil, **as directed**.
  - b. Accumulator.
  - c. Constant-pressure expansion valve.
  - d. Reversing valve.
  - e. Charge: R-407C **OR** R-410A, **as directed**.
3. Indoor Fan: Forward curved, centrifugal; with motor and positive-pressure ventilation damper with concealed manual **OR** electric, **as directed**, operator.
4. Filters: Washable polyurethane in molded plastic frame.
5. Condensate Drain: Drain pan to direct condensate to outdoor coil for re-evaporation **OR** and piping to direct condensate to building waste and vent piping, **as directed**.
  - a. Comply with ASHRAE 62.1 for drain pan construction and connections.
6. Outdoor Fan: Forward curved, centrifugal **OR** Propeller, **as directed**, type with separate **OR** driven by indoor fan, **as directed**, motor.
  - a. Indoor and Outdoor Fan Motors: Two speed; comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - 1) Fan Motors: Permanently lubricated split capacitor.
    - 2) Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

- 3) Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

C. Heating

1. Electric-Resistance Heating Coil: Nickel-chromium-wire, electric-resistance heating elements with contactor and high-temperature-limit switch.  
**OR**  
Hot-Water Heating Coil: Seamless copper tubes mechanically expanded into aluminum fins with two-way modulating control valve and air vent.  
**OR**  
Gas Heat:
  - a. General Requirements for Gas-Fired, Noncondensing Furnaces: Factory assembled, piped, wired, and tested; complying with ANSI Z21.86/CSA 2.32, "Vented Gas-Fired Space Heating Appliances," and with NFPA 54.
  - b. Type of Gas: Natural **OR** Propane, **as directed**.
  - c. Heat Exchanger: Aluminized-steel **OR** Stainless steel, **as directed**.
  - d. Burner:
    - 1) Gas Valve: 100 percent safety two-stage **OR** modulating, **as directed**, main gas valve, main shutoff valve, pressure regulator, safety pilot with electronic flame sensor, limit control, transformer, and combination ignition/fan timer control board.
    - 2) Ignition: Electric pilot ignition with hot-surface igniter or electric spark ignition.
  - e. Gas-Burner Safety Controls:
    - 1) Electronic Flame Sensor: Prevents gas valve from opening until pilot flame is proven; stops gas flow on ignition failure.
    - 2) Flame Rollout Switch: Installed on burner box; prevents burner operation.
    - 3) Limit Control: Fixed stop at maximum permissible setting; de-energizes burner on excessive bonnet temperature; automatic reset.
  - f. Combustion-Air Inducer: Centrifugal fan prepurges heat exchanger and vents combustion products; thermally protected motor with sleeve bearings; pressure switch prevents operation if combustion-air inlet or flue outlet is blocked.
  - g. Furnace Controls: Solid-state board integrates ignition, heat, cooling, and fan speeds; adjustable fan-on and fan-off timing; and terminals for connection to accessories.

D. Controls

1. Control Module: Unit-mounted digital panel with touchpad temperature control and with touchpad for heating, cooling, and fan operation. Include the following features:
  - a. Low Ambient Lockout Control: Prevents cooling-cycle operation below **40 deg F (5 deg C)** outdoor air temperature.
  - b. Heat-Pump Ambient Control: Field-adjustable switch changes to heat-pump heating operation above **40 deg F (5 deg C)** and to supplemental heating below **plus 25 deg F (minus 4 deg C)**.
  - c. Temperature-Limit Control: Prevents occupant from exceeding preset setback **OR** setup, **as directed**, temperature.
  - d. Building Automation System Interface: Allows remote on-off control with setback temperature control.
  - e. Reverse-Cycle Defrost: Solid-state sensor monitors frost buildup on indoor **OR** outdoor, **as directed**, coil and reverses unit to melt frost.
2. Remote Control: Standard unit-mounted controls with remote-mounted, low-voltage adjustable thermostat with heat anticipator, heat-off-cool-auto **OR** heat-off-cool, **as directed**, switch, and on-auto, **as directed**, fan switch.
3. Outdoor Air: Manual **OR** Motorized, **as directed**, intake damper. Open intake when unit indoor air fan runs, **as directed**.

E. Source Quality Control

1. Sound-Power Level Ratings: Factory test to comply with ARI 300, "Sound Rating and Sound Transmission Loss of Packaged Terminal Equipment."

2. Unit Performance Ratings: Factory test to comply with ARI 310/380/CSA C744, "Packaged Terminal Air-Conditioners and Heat Pumps."

### 1.3 EXECUTION

#### A. Installation

1. Install units level and plumb, maintaining manufacturer's recommended clearances and tolerances.
2. Install wall sleeves in finished wall assembly; seal and weatherproof. Joint-sealant materials and applications are specified in Division 07 Section "Joint Sealants".
3. Install and anchor wall sleeves to withstand, without damage to equipment and structure, seismic forces required by building code.

#### B. Connections

1. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
2. Comply with requirements for piping specified in Division 23 Section "Facility Natural-gas Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
3. Install piping adjacent to machine to allow service and maintenance.

#### C. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
  - a. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - b. After installing packaged terminal air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
  - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Packaged terminal air conditioners will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

#### D. Startup Service

1. Perform startup service.
2. After installation, verify the following:
  - a. Unit is level on base and is flashed in exterior wall.
  - b. Unit casing has no visible damage.
  - c. Compressor, air-cooled condenser coil, and fans have no visible damage.
  - d. Labels are clearly visible.
  - e. Controls are connected and operable.
  - f. Shipping bolts, blocks, and tie-down straps are removed.
  - g. Filters are installed and clean.
  - h. Drain pan and drain line are installed correctly.
  - i. Electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 22.
  - j. Installation. Perform startup checks according to manufacturer's written instructions, including the following:
    - 1) Lubricate bearings on fan.
    - 2) Check fan-wheel rotation for correct direction without vibration and binding.
3. After startup service and performance test, change filters.

#### E. Adjusting

1. Adjust initial temperature set points.
  2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- F. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain packaged terminal air conditioners.

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Task	Specification	Specification Description
23 81 13 13	23 81 13 11	Packaged Terminal Air Conditioners
23 81 16 00	23 81 13 11	Packaged Terminal Air Conditioners

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## SECTION 23 81 23 12 - COMPUTER-ROOM AIR-CONDITIONERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for computer-room air-conditioners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Floor-mounted computer-room air conditioners, 6 tons (21 kW) and larger.
  - b. Floor-mounted computer-room air conditioners, 5 tons (18 kW) and smaller.
  - c. Ceiling-mounted computer-room air conditioners.
  - d. Console computer-room air conditioners.

#### C. Definition

1. BAS: Building automation system.

#### D. Performance Requirements

1. Seismic Performance: Computer-room air conditioners shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
  - a. Product Data for Credit EA 4: Documentation required by Credit EA 4 indicating that equipment and refrigerants comply.
  - b. Product Data for Prerequisite EQ 1: Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
3. Shop Drawings: For computer-room air conditioners. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Wiring Diagrams: For power, signal, and control wiring.
4. Color Samples: For unit cabinet, discharge grille, and exterior louver and for each color and texture specified.
5. Seismic Qualification Certificates: For computer-room air conditioners, accessories, and components, from manufacturer.
6. Field quality-control reports.
7. Operation and maintenance data.
8. Warranty: Sample of special warranty.

#### F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. ASHRAE Compliance:
  - a. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."



- b. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Ventilation Rate Procedures," and Section 7 - "Construction and Startup."
- 3. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.
- 4. ASME Compliance: Fabricate and label water-cooled condenser shell to comply with ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," Division 1.

G. Warranty

- 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of computer-room air conditioners that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period for Compressors: Manufacturer's standard, but not less than five **OR** 10, **as directed**, years from date of Final Completion.
  - b. Warranty Period for Humidifiers: Manufacturer's standard, but not less than three years from date of Final Completion.
  - c. Warranty Period for Control Boards: Manufacturer's standard, but not less than three years from date of Final Completion.

1.2 PRODUCTS

A. Floor-Mounted Units **6 Tons (21 kW)** And Larger

- 1. Description: Packaged, factory assembled, prewired, and prepiped; consisting of cabinet, fans, filters, humidifier, and controls.
- 2. Cabinet and Frame: Welded steel, braced for rigidity, and supporting compressors and other mechanical equipment and fittings.
  - a. Doors and Access Panels: Galvanized steel with polyurethane gaskets, hinges, and concealed fastening devices.
  - b. Insulation: Thermally and acoustically insulate cabinet interior with **1-inch- (25-mm-)** thick duct liner.
  - c. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  - d. Finish of Exterior Surfaces: Baked-on, textured vinyl enamel; color as selected from manufacturer's standard colors **OR** to match computer equipment, **as directed**.
  - e. Floor Stand: Welded tubular steel with adjustable legs and vibration isolation pads.
- 3. Supply-Air Fan(s):
  - a. Double-inlet, forward-curved centrifugal fan(s); statically and dynamically balanced.
  - b. Drive: V-belt, with steel shaft with self-aligning ball bearings and cast-iron or steel sheaves, variable- and adjustable-pitch motor sheave, minimum of two matched belts, with drive rated at a minimum of two times the nameplate rating of motor.
- 4. Refrigeration System:
  - a. Compressors: Semihermetic reciprocating; with suction-gas-cooled, 1750-rpm motors; thermal overloads; oil sight glass; suction-line strainer; and reversible oil pumps; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.  
**OR**  
Compressors: Hermetic reciprocating; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.  
  
Compressors: Hermetic scroll; with oil strainer, internal motor overload protection, **as directed**, resilient suspension system, crankcase heater, manual-reset high-pressure switch, and pump-down low-pressure switch.

- b. Refrigeration Circuits: Two; each with hot-gas mufflers, thermal-expansion valve with external equalizer, liquid-line solenoid valve, liquid-line filter-dryer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
- c. Refrigerant: R-407C **OR** R-410A, **as directed**.
- d. Refrigerant Evaporator Coil: Alternate-row or split-face-circuit, direct-expansion coil of seamless copper tubes expanded into aluminum fins.
  - 1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
- e. Integral, Water-Cooled Refrigerant Condenser: Shell-and-tube type fabricated and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII **OR** Coaxial tube-in-tube type, **as directed**, with liquid-line stop valve and head-pressure-actuated, two-way **OR** three-way, **as directed**, regulating valve. Terminate fluid connections outside cabinet.
  - 1) Cooling Medium: Water **OR** Glycol solution, **as directed**.

**OR**

Remote Air-Cooled Refrigerant Condenser: Corrosion-resistant cabinet, copper-tube aluminum-fin coils arranged for two circuits, multiple direct-drive propeller fans with permanently lubricated ball bearings, and single-phase motors with internal overload protection and integral electric control panel and disconnect switch, **as directed**. Control capacity by cycling fans **OR** modulating fan speeds **OR** three-way refrigerant bypass with receiver and isolation valve, **as directed**.
- 5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating two-way **OR** three-way, **as directed**, control valve.
  - a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
  - b. Control Valve: Class 125 body.
    - 1) Maximum Pressure Drop: **3 psig (21 kPa) OR 5 psig (35 kPa)**, **as directed**, at design flow rate.
    - 2) Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.
  - c. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

**OR**

Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, multiple direct-drive propeller fans with fan guards, and single-phase motors with internal overload protection and integral electric control panel. Control capacity by cycling fans.

- d. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- 6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing one **OR** two, **as directed**, centrifugal pump(s) with mechanical seals; electrical-control cabinet with starters, lead-lag switch, automatic switchover, and alarm light.
  - a. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, check valves in pump discharge, unions, and pressurized expansion tank with air purge vent and system-charging connection.
  - b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of **minus 40 deg F (minus 40 deg C)**.
  - c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- 7. Electric-Resistance Heating Coil: Enclosed finned-tube electric elements arranged for minimum of three stages, with thermal safety switches, manual-reset overload protection, and branch-circuit overcurrent protection.
 

**OR**

Refrigerant Heating Coil: Hot-gas coil of seamless copper tubes expanded into aluminum fins with three-way solenoid valve on first-stage refrigerant circuit.

**OR**



Hot-Water Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve and strainer.

- a. Control Valve: Class 125 body.
  - 1) Maximum Pressure Drop: **3 psig (21 kPa) OR 5 psig (35 kPa)**, as directed, at design flow rate.
  - 2) Close-Off (Differential) Pressure Rating: 100 percent of pressure differential across valve or 100 percent of total system (pump) head.

**OR**

Steam Heating Coil: Seamless copper tubes expanded into aluminum fins with two-way modulating control valve, strainer, and float-and-thermostatic trap.

- b. Control Valve: Class 125 body.
  - 1) Maximum Pressure Drop (**15-psig (103-kPa) Steam**): 80 percent of inlet steam pressure.
  - 2) Close-Off (Differential) Pressure Rating: 150 percent of operating (inlet) pressure.
8. Extended-Surface, Disposable, Panel Filter: Pleated, lofted, nonwoven, reinforced cotton fabric; supported and bonded to welded-wire grid; enclosed in cardboard frame with **2-inch- (50-mm-)** thick, disposable, glass-fiber prefilter, **as directed**.
  - a. Thickness: **2 inches (50 mm) OR 4 inches (100 mm)**, as directed.
  - b. Initial Resistance: as directed by the Owner.
  - c. Recommended Final Resistance: as directed by the Owner.
  - d. Arrestance (ASHRAE 52.1): 90 percent.
  - e. Merv (ASHRAE 52.2): 7.
9. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepped and using condensate water from cooling coils with stainless-steel or brass float-valve mechanism; located in bypass airstream; with flush-cycle timer and solenoid drain valve.
10. Evaporative Pan Humidifier: Stainless-steel pan and cover, serviceable without disconnecting water, drain, or electrical connections; prepped with stainless-steel or brass float-valve mechanism; electric-resistance heating coil; low-water-cutoff switch; flush-cycle timer; and solenoid drain valve.
11. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
  - a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
  - b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
  - c. Drain Cycle: Field-adjustable drain duration and drain interval.
12. Integral Electrical Controls: Unit-mounted electrical enclosure with piano-hinged door, grounding lug, combination magnetic starters with overload relays, circuit breakers and cover interlock, and fusible control-circuit transformer.
13. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
14. Electronic-Control System: Solid state, with start button, stop button, temporary loss of power indicator, manual-reset circuit breakers, temperature control, humidity control, and monitor panel.
  - a. Monitor Panel: Backlighted, with no visible indicator lights until operating function is activated; indicators include cooling, humidification, loss of airflow, change filters, high temperature, low temperature, high humidity, low humidity, high head pressure (each compressor), and low suction pressure (each compressor).
  - b. Temperature- and Humidity-Control Modules: Solid state, plug-in; with adjustable set point, push-to-test calibration check button, and built-in visual indicators to show mode of operation.
  - c. Location: Behind hinged door in front of unit; isolated from conditioned airstream to allow service while system is operating.



15. Microprocessor-Control System: Continuously monitors operation of process cooling system; continuously displays room temperature and room relative humidity; sounds alarm on system malfunction and simultaneously displays problem. If more than one malfunction occurs, system displays fault in sequence with room temperature and continues to display fault when malfunction is cleared until system is reset.

a. Malfunctions:

- 1) Power loss.
- 2) Loss of airflow.
- 3) Clogged air filter.
- 4) High room temperature.
- 5) Low room temperature.
- 6) High humidity.
- 7) Low humidity.
- 8) Smoke/fire.
- 9) Water under floor.
- 10) Supply fan overload.
- 11) Compressor No. 1 - Overload.
- 12) Compressor No. 1 - Low Pressure.
- 13) Compressor No. 1 - High Pressure.
- 14) Compressor No. 2 - Overload.
- 15) Compressor No. 2 - Low Pressure.
- 16) Compressor No. 2 - High Pressure.

b. Digital Display:

- 1) Control power on.
- 2) Humidifying.
- 3) Dehumidifying.
- 4) Compressor No. 1 - Operating.
- 5) Compressor No. 2 - Operating.
- 6) Heat operating.
- 7) Economy cooling.

- c. Push buttons shall stop and start process cooling system, silence audible alarm, test indicators, and display room's relative humidity.

- d. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display unit status and alarms.

1) Hardwired Points:

- a) Monitoring: On-off status, common trouble alarm **OR** space temperature **OR** space relative humidity, **as directed**.
- b) Control: On-off operation, space temperature set-point adjustment **OR** space relative humidity set-point adjustment, **as directed**.

- 2) ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor the unit from an operator workstation. Control features and monitoring points displayed locally at unit control panel shall be available through the BAS.

B. Floor-Mounted Units **5 Tons (18 kW)** And Smaller

1. Description: Self-contained, factory assembled, prewired, and prepiped; consisting of cabinet, fan, filters, and controls; for vertical floor mounting in upflow or downflow configuration.
2. Cabinet and Frame: Welded tubular-steel frame with removable steel panels with baked-enamel finish, insulated with **1-inch- (25-mm-)** thick duct liner.
  - a. Floor Stand: Welded tubular steel with adjustable legs and vibration isolation pads.
  - b. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Supply-Air Fan: Forward curved, centrifugal, and with adjustable V-belt drive.
4. Refrigeration System:

- a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
- b. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
- c. Refrigerant: R-407C **OR** R-410A, **as directed**.
- d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins, with two circuits, each with solenoid valve.
  - 1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
- e. Integral, Water-Cooled Refrigerant Condenser: Braze-plate type with liquid-line stop valve and head-pressure-actuated, two-way regulating valve.
  - 1) Cooling Medium: Water **OR** Glycol solution, **as directed**.

**OR**

Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct **OR** belt, **as directed**, driven.

  - 2) Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
- 5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating three-way control valve.
  - a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
  - b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

**OR**

Remote Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.

  - c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- 6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
  - a. Piping: Interconnecting piping, from suction to discharge, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
  - b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of **minus 40 deg F (minus 40 deg C)**.
  - c. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- 7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.
- 8. Filter: **2-inch- (50-mm-)** thick, disposable, glass-fiber media.
  - a. Initial Resistance: as directed by the Owner.
  - b. Recommended Final Resistance: as directed by the Owner.
  - c. Arrestance (ASHRAE 52.1): 90 percent.
  - d. Merv (ASHRAE 52.2): 7.
- 9. Infrared Humidifier: High-intensity quartz lamps mounted above stainless-steel evaporator pan, serviceable without disconnecting water, drain, or electrical connections; prepiped and located in bypass airstream; with flush-cycle timer and solenoid drain valve.
- 10. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.

- a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
  - b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
  - c. Drain Cycle: Field-adjustable drain duration and drain interval.
  11. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
  12. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature- and humidity-, **as directed**, control modules, humidity contactor, **as directed**, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.
- C. Ceiling-Mounted Units
1. Description: Self-contained, factory assembled, prewired, and prepped; consisting of cabinet, fan, filters, and controls; for horizontal ceiling mounting to fit T-bar ceiling opening of **24 by 48 inches (610 by 1220 mm)**.
  2. Cabinet: Galvanized steel with baked-enamel finish, insulated with **1/2-inch- (13-mm-)** thick duct liner.
    - a. Integral factory-supplied supply and return grille to fit ceiling grid kit of **24 by 48 inches (610 by 1220 mm)**, with filter.
    - b. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
  3. Supply-Air Fan: Forward curved, centrifugal, and directly driven by two-speed motor.
  4. Refrigeration System:
    - a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
    - b. Refrigeration Circuit: Low-pressure switch, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
    - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
    - d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
      - 1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.
    - e. Integral, Water-Cooled Refrigerant Condenser: Coaxial, counterflow, tube-in-tube **OR** Brazed-plate, **as directed**, type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.
      - 1) Cooling Medium: Water **OR** Glycol solution, **as directed**.

**OR**

Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct driven.
    - f. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
  5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with two-way control valve.
    - a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
    - b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

**OR**

Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motors with internal overload protection.

6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
  - a. Piping: Interconnecting piping, to and from remote, air-cooled glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
  - b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of **minus 40 deg F (minus 40 deg C)**.
7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor, dehumidification relay, and high-temperature-limit switches.
8. Filter: **1-inch- (25-mm-)** thick, disposable, glass-fiber media.
  - a. Initial Resistance: as directed by the Owner.
  - b. Recommended Final Resistance: as directed by the Owner.
  - c. Arrestance (ASHRAE 52.1): 90 percent.
  - d. Merv (ASHRAE 52.2): 7.
9. Atomizing Humidifier: Centrifugal atomizer with stainless-steel pan, demister pad, and solenoid valve.
10. Electrode Steam Humidifier: Self-contained, microprocessor-controlled unit with disposable, polypropylene-plastic cylinders, and having field-adjustable steel electrodes and stainless-steel steam dispersion tube.
  - a. Plumbing Components and Valve Bodies: Plastic, linked by flexible rubber hosing, with water fill with air gap and solenoid valve incorporating built-in strainer, pressure-reducing and flow-regulating orifice, and drain with integral air gap.
  - b. Control: Fully modulating to provide gradual 0 to 100 percent capacity with field-adjustable maximum capacity; with high-water probe.
  - c. Drain Cycle: Field-adjustable drain duration and drain interval.
11. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
12. Control System: Unit-mounted panel with main fan contactor, compressor contactor, compressor start capacitor, control transformer with circuit breaker, solid-state temperature- and humidity-, **as directed**, control modules, humidity contactor, **as directed**, time-delay relay, heating contactor, and high-temperature thermostat. Provide solid-state, wall-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.

D. Console Units

1. Description: Split system consisting of evaporator section for floor or wall mounting and remote condensing section.
2. Evaporator Cabinet: Furniture-grade steel with baked-enamel finish; with front access and containing direct-drive centrifugal fans and two-speed motor.
  - a. Finish of Interior Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
3. Condenser Cabinet: Steel with baked-enamel finish and containing compressor and condenser.
4. Refrigeration System:
  - a. Compressor: Hermetic, with oil strainer, internal motor overload protection, resilient suspension system, and crankcase heater.
  - b. Refrigeration Circuit: Filter/dryer, manual-reset high-pressure switch, thermal-expansion valve with external equalizer, sight glass with moisture indicator, service shutoff valves, charging valves, and charge of refrigerant.
  - c. Refrigerant: R-407C **OR** R-410A, **as directed**.
  - d. Refrigerant Evaporator Coil: Direct-expansion coil of seamless copper tubes expanded into aluminum fins.
    - 1) Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.

- e. Integral, Water-Cooled Refrigerant Condenser: Coaxial, counterflow, tube-in-tube **OR** Brazed-plate, **as directed**, type with liquid-line stop valve and head-pressure-actuated, water-regulating valve.  
**OR**  
Remote Air-Cooled Refrigerant Condenser: Integral, copper-tube aluminum-fin coil with propeller **OR** centrifugal, **as directed**, fan, direct driven.
- f. Split system shall have suction- and liquid-line compatible fittings and refrigerant piping for field interconnection.
- 5. Hydronic Cooling Coil: Seamless copper tubes expanded into aluminum fins with modulating control valve.
  - a. Cooling Medium: Water **OR** Glycol solution, **as directed**.
  - b. Mount coil assembly over stainless-steel drain pan complying with ASHRAE 62.1, **as directed**, and having a condensate pump unit with integral float switch, pump-motor assembly, and condensate reservoir, **as directed**.**OR**  
Remote, Air-Cooled, Glycol-Solution Cooler: Corrosion-resistant cabinet, copper-tube aluminum-fin coil, direct-drive propeller fan with fan guards, and single-phase motor with internal overload protection.
- 6. Glycol-Solution Pump Package: Weatherproof and vented enclosure of enameled, galvanized steel on structural base frame containing centrifugal pump with mechanical seal.
  - a. Piping: Interconnecting piping, to and from remote, air-cooled, glycol-solution cooler, with shutoff valves, flow switches, unions, and pressurized expansion tank with air purge vent and system-charging connection.
  - b. Glycol: Inhibited ethylene glycol and water solution mixed 50:50, suitable for operating temperature of **minus 40 deg F (minus 40 deg C)**.
- 7. Electric-Resistance Heating Coil: Finned-tube electric elements with contactor and high-temperature-limit switches.
- 8. Filter: Cleanable.  
**OR**  
Filter: **1-inch- (25-mm-)** thick, disposable, glass-fiber media.
  - a. Initial Resistance: as directed by the Owner.
  - b. Recommended Final Resistance: as directed by the Owner.
  - c. Arrestance (ASHRAE 52.1): 90 percent.
  - d. Merv (ASHRAE 52.2): 7.
- 9. Electrode Steam Humidifier: Self-contained and microprocessor controlled; with replaceable cylinder.
- 10. Disconnect Switch: Nonautomatic, molded-case circuit breaker with handle accessible when panel is closed and capable of preventing access until switched to off position.
- 11. Control System: Unit-mounted panel with contactors, control transformer with circuit breaker, and solid-state temperature- and humidity-, **as directed**, control modules. Provide solid-state, unit-mounted control panel with start-stop switch, adjustable humidity set point, **as directed**, and adjustable temperature set point.
- E. Fan Motors
  - 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - b. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.

### 1.3 EXECUTION

#### A. Installation



1. Install computer-room air conditioners level and plumb, maintaining manufacturer's recommended clearances. Install according to ARI Guideline B, **as directed**.
2. Computer-Room Air-Conditioner Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1 inch (25 mm), as directed**.
3. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and elastomeric hangers **OR** spring hangers **OR** spring hangers with vertical-limit stop, **as directed**, of size required to support weight of computer-room air conditioner.
  - a. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment". Fabricate brackets or supports as required.
  - b. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers And Supports For Hvac Piping And Equipment".
4. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1 inch (25 mm), as directed**.
5. Remote, Air-Cooled, Glycol-Solution Cooler Mounting: Install using elastomeric pads **OR** elastomeric mounts **OR** restrained spring isolators, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
  - a. Minimum Deflection: **1/4 inch (6 mm) OR 1 inch (25 mm), as directed**.
6. Glycol-Solution Pump Package Mounting: Install using elastomeric pads **OR** elastomeric mounts, **as directed**. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".

**B. Connections**

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to machine to allow service and maintenance.
3. Water and Drainage Connections: Comply with applicable requirements in Division 22 Section "Domestic Water Piping". Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
4. Hot-Water Heating Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Provide shutoff valves in inlet and outlet piping to heating coils.
5. Steam and Condensate Piping: Comply with applicable requirements in Division 23 Section "Steam And Condensate Heating Piping". Provide shutoff valves in steam inlet and steam trap in condensate outlet piping to heating coils.
6. Condenser-Water Piping: Comply with applicable requirements in Division 23 Section "Hydronic Piping". Provide shutoff valves in water inlet and outlet piping on water-cooled units.
7. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping". Provide shutoff valves and piping.

**C. Field Quality Control**

1. Perform tests and inspections.
2. Tests and Inspections:
  - a. Inspect for and remove shipping bolts, blocks, and tie-down straps.
  - b. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
  - c. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

- d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  3. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
  4. Prepare test and inspection reports.
  5. After startup service and performance test, change filters and flush humidifier.
- D. Adjusting
1. Adjust initial temperature and humidity, **as directed**, set points.
  2. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- E. Demonstration
1. Train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

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Task	Specification	Specification Description
23 81 23 13	23 81 23 12	Computer-Room Air-Conditioners
23 81 43 00	23 81 13 11	Packaged Terminal Air Conditioners
23 81 49 00	23 63 13 00a	Split-System Air-Conditioning Units

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## SECTION 23 82 16 11 - AIR COILS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for air coils. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following types of air coils that are not an integral part of air-handling units:
  - a. Hot-water.
  - b. Chilled-water.
  - c. Steam.
  - d. Refrigerant.
  - e. Electric.

#### C. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil. Include rated capacity and pressure drop for each air coil.
2. Shop Drawings: Diagram power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and maintenance data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. ASHRAE Compliance:
  - a. Comply with ASHRAE 15 for refrigeration system safety.
  - b. Comply with ASHRAE 33 for methods of testing cooling and heating coils.
  - c. Comply with applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

### 1.2 PRODUCTS

#### A. Water Coils

1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure/Temperature Ratings: **200 psig (1380 kPa), 325 deg F (163 deg C).**
3. Source Quality Control: Factory tested to **300 psig (2070 kPa).**
4. Tubes: ASTM B 743 copper, minimum **0.020 inch (0.508 mm) OR 0.035 inch (0.889 mm) OR 0.049 inch (1.245 mm), as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum **0.006 inch (0.152 mm) OR 0.010 inch (0.254 mm), as directed**, thick.
6. Headers: Cast iron with drain and air vent tapings **OR** Cast iron with cleaning plugs, and drain and air vent tapings **OR** Seamless copper tube with brazed joints, prime coated **OR** Steel with brazed joints, prime coated, **as directed**.
7. Frames: Galvanized-steel channel frame, minimum **0.052 inch (1.3 mm) OR 0.064 inch (1.6 mm) OR 0.079 inch (2.0 mm) OR 0.0625 inch (1.6 mm), as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.

**OR**

Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum **0.0625 inch (1.6 mm)** thick for slip-in **OR** flanged, **as directed**, mounting.

8. Hot-Water Coil and Steam Coil, Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.
  - a. Coil Configuration: Horizontal **OR** Vertical, **as directed**, tubes.
  - b. Dampers: Extruded-aluminum **OR** Galvanized-steel, **as directed**, blades with edge and end seals; full-length drive rod and mount for actuator in **OR** outside, **as directed**, the airstream.

**B. Steam Coils**

1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure/Temperature Ratings: **100 psig (690 kPa), 400 deg F (204 deg C).**
3. Source Quality Control: Factory tested to **300 psig (2070 kPa).**
4. Tubes: ASTM B 743 copper, minimum **0.025 inch (0.635 mm) OR 0.035 inch (0.889 mm) OR 0.049 inch (1.245 mm), as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum **0.006 inch (0.152 mm) OR 0.010 inch (0.254 mm), as directed**, thick.
6. Headers: Cast iron with drain and air vent tapings **OR** Cast iron with cleaning plugs, and drain and air vent tapings **OR** Seamless copper tube with brazed joints, prime coated **OR** Steel with brazed joints, prime coated, **as directed**.
7. Tube Type: Single or distributing as indicated.
8. Frames: Galvanized-steel channel frame, minimum **0.052 inch (1.3 mm) OR 0.064 inch (1.6 mm) OR 0.079 inch (2.0 mm) OR 0.0625 inch (1.6 mm), as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.

**OR**

Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum **0.0625 inch (1.6 mm)** thick for slip-in **OR** flanged, **as directed**, mounting.

9. Face-and-Bypass Dampers: Alternating arrangement of coil segments and dampers.
  - a. Coil Configuration: Horizontal **OR** Vertical, **as directed**, tubes.
  - b. Dampers: Extruded-aluminum **OR** Galvanized-steel, **as directed**, blades with edge and end seals; full-length drive rod and mount for actuator in **OR** outside, **as directed**, the airstream.

**C. Refrigerant Coils**

1. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.
2. Minimum Working-Pressure Rating: **300 psig (2070 kPa).**
3. Source Quality Control: Factory tested to **450 psig (3105 kPa).**
4. Tubes: ASTM B 743 copper, minimum **0.020 inch (0.508 mm) OR 0.035 inch (0.889 mm) OR 0.049 inch (1.245 mm), as directed**, thick.
5. Fins: Aluminum **OR** Copper, **as directed**, minimum **0.006 inch (0.152 mm) OR 0.010 inch (0.254 mm), as directed**, thick.
6. Suction and Distributor Piping: **ASTM B 88, Type L (ASTM B 88M, Type B)** copper tube with brazed joints.
7. Frames: Galvanized-steel channel frame, minimum **0.052 inch (1.3 mm) OR 0.064 inch (1.6 mm) OR 0.079 inch (2.0 mm) OR 0.0625 inch (1.6 mm), as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.

**OR**

Frames: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel, minimum **0.0625 inch (1.6 mm)** thick for slip-in **OR** flanged, **as directed**, mounting.

**D. Electric Coils**

1. Coil Assembly: Comply with UL 1995.

2. Heating Elements: Coiled resistance wire of 80 percent nickel and 20 percent chromium; surrounded by compacted magnesium-oxide powder in tubular-steel sheath; with spiral-wound, copper-plated, steel fins continuously brazed to sheath.  
**OR**  
Heating Elements: Open-coil resistance wire of 80 percent nickel and 20 percent chromium, supported and insulated by floating ceramic bushings recessed into casing openings, and fastened to supporting brackets.
3. High-Temperature Coil Protection: Disk-type, automatically reset, thermal-cutout, safety device; serviceable through terminal box without removing heater from duct or casing.
  - a. Secondary Protection: Load-carrying, manually reset or manually replaceable, thermal cutouts; factory wired in series with each heater stage.
4. Frames: Galvanized-steel channel frame, minimum **0.052 inch (1.3 mm) OR 0.064 inch (1.6 mm) OR 0.079 inch (2.0 mm) OR 0.0625 inch (1.6 mm)**, **as directed**, thick for slip-in **OR** flanged, **as directed**, mounting.
5. Control Panel: Unit **OR** Remote, **as directed**, mounted with disconnecting means and overcurrent protection. Include the following controls:
  - a. Magnetic contactor.
  - b. Mercury contactor.
  - c. Toggle switches; one per step.
  - d. Step controller.
  - e. Time-delay relay.
  - f. Pilot lights; one per step.
  - g. Airflow proving switch.
6. Refer to Division 23 Section "Instrumentation And Control For Hvac" for thermostat.  
**OR**  
Thermostats: Wall-mounted thermostats, with temperature range from **50 to 90 deg F (10 to plus 32 deg C)**, and **2.5 deg F (1.4 deg C)** throttling range.

### 1.3 EXECUTION

#### A. Installation

1. Install coils level and plumb.
2. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
3. Install galvanized-steel **OR** stainless-steel, **as directed**, drain pan under each cooling coil.
  - a. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1, **as directed**.
  - b. Construct drain pans to extend beyond coil length and width and to connect to condensate trap and drainage.
  - c. Extend drain pan upstream and downstream from coil face.
  - d. Extend drain pan under coil headers and exposed supply piping.
4. Install moisture eliminators for cooling coils. Extend drain pan under moisture eliminator.
5. Straighten bent fins on air coils.
6. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

#### B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Install piping adjacent to coils to allow service and maintenance.
3. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping. Control valves are specified in Division 23 Section "Instrumentation And Control For Hvac", and other piping specialties are specified in Division 23 Section "Hydronic Piping".
4. Connect steam piping with gate valve and union and steam condensate piping with union, strainer, trap, and gate valve to allow coils to be disconnected without draining piping. Control



valves are specified in Division 23 Section "Instrumentation And Control For Hvac", and other piping specialties are specified in Division 23 Section "Steam And Condensate Heating Piping".

5. Connect refrigerant piping according to Division 23 Section "Refrigerant Piping".
6. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
7. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
  - a. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
  - b. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 23 82 16 11

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Task	Specification	Specification Description
23 82 16 12	23 82 16 11	Air Coils
23 82 16 13	23 82 16 11	Air Coils
23 82 16 14	23 74 16 13b	Unit Ventilators
23 82 19 00	23 64 16 16	Fan-Coil Units

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## SECTION 23 82 29 00 - CONVECTION HEATING UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for convection heating units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Hydronic, Steam, and Electric baseboard radiators.
  - b. Hydronic, Steam, and Electric finned-tube radiators.
  - c. Hydronic, Steam, and Electric convectors.
  - d. Flat-pipe steel radiators.

#### C. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories for each type of product indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Field quality-control test reports.
4. Operation and maintenance data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### 1.2 PRODUCTS

#### A. Electric Baseboard Radiators

1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded to fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.
3. Enclosures: Minimum **0.0329-inch- (0.85-mm-) OR 0.0428-inch- (1.1-mm-), as directed**, thick steel, removable front cover.
4. Rust-Resistant Enclosures: Minimum **0.040-inch- (1.0-mm-) OR 0.052-inch- (1.3-mm-), as directed**, thick ASTM A 653/A 653M, G60 galvanized-steel, removable front cover.
  - a. Full-height back.
  - b. Full-length damper.
  - c. End panel.
  - d. Plastic end **OR** End, **as directed**, caps.
  - e. Inside and outside corners.
  - f. Joiner pieces to snap together.
  - g. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
  - h. Element Brackets: Primed and painted steel to support front panel and element.
5. Unit Controls: Integral line-voltage thermostat **OR** Integral electronic thermostat **OR** Remote line-voltage thermostat, **as directed**.



6. Accessories:
  - a. Filler sections without a heating element matching the adjacent enclosure.
  - b. Straight-blade-type receptacles complying with DSCC W-C-596G/GEN, NEMA WD 1, NEMA WD 6, and UL 498; in color selected.

B. Hot-Water Baseboard Radiators

1. Performance Ratings: Rate baseboard radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Baseboard Radiation."
2. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on polypropylene element glides. One end of tube shall be belled.
  - a. Tube Diameter: **NPS 1/2 (DN 15) OR NPS 3/4 (DN 20) OR NPS 1 (DN 25) OR NPS 1-1/4 (DN 32), as directed.**
  - b. Fin Size: **2-1/2 by 2-1/2 inches (63 by 63 mm) OR 3 by 3 inches (76 by 76 mm), as directed.**
  - c. Fin Spacing: **40 per foot (131 per meter) OR 50 per foot (164 per meter) OR 58 per foot (190 per meter), as directed.**
  - d. Entering Air Temperature: **65 deg F (18 deg C).**
  - e. Average Water Temperature: **180 deg F (82 deg C).**
  - f. Minimum Water Velocity: **1/2 fps (0.15 m/s).**
  - g. Entering Steam Pressure: **1 psig (6.9 kPa).**
3. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on polypropylene element glides. Tube ends shall be threaded.
  - a. Tube Diameter: **NPS 1-1/4 (DN 32).**
  - b. Fin Size: **3 by 3 inches (76 by 76 mm).**
  - c. Fin Spacing: **52 per foot (171 per meter).**
  - d. Entering Air Temperature: **65 deg F (18 deg C).**
  - e. Average Water Temperature: **180 deg F (82 deg C).**
  - f. Minimum Water Velocity: **1/2 fps (0.15 m/s).**
  - g. Entering Steam Pressure: **1 psig (6.9 kPa).**
4. Enclosures: Minimum **0.0329-inch- (0.85-mm-) OR 0.0428-inch- (1.1-mm-), as directed**, thick steel, removable front cover.
5. Rust-Resistant Enclosures: Minimum **0.040-inch- (1.0-mm-) OR 0.052-inch- (1.3-mm-), as directed**, thick ASTM A 653/A 653M, G60 galvanized-steel, removable front cover.
  - a. Full-height back.
  - b. Full-length damper.
  - c. End panel.
  - d. End caps.
  - e. Inside and outside corners.
  - f. Valve access door.
  - g. Joiner pieces to snap together.
  - h. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
  - i. Element Brackets: Primed and painted steel to support front panel and element.

C. Electric Finned-Tube Radiators

1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded into fins, with high-temperature cutout and sensor running the full length of the element. Element supports shall eliminate thermal expansion noise.
3. Front Panel: Minimum **0.0428-inch- (1.1-mm-) OR 0.0528-inch- (1.35-mm-), as directed**, thick steel.
4. Rust-Resistant Front Panel: Minimum **0.052-inch- (1.3-mm-) OR 0.064-inch- (1.6-mm-), as directed**, thick ASTM A 653/A 653M, G60 galvanized steel.
5. Wall-Mounting Back Panel: Minimum **0.0329-inch- (0.85-mm-)** thick steel, full height, with full-length channel support for front panel without exposed fasteners.

6. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum **36-inch (914-mm)** spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
  7. Support Brackets: Locate at maximum **36-inch (914-mm)** spacing to support front panel and element.
  8. Finish: Baked-enamel **OR** epoxy, **as directed**, finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
  9. Damper: Knob-operated internal damper at enclosure outlet.
  10. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size **6 by 7 inches (150 by 175 mm)**, integral with enclosure.
  11. Enclosure Style: Sloped **OR** Flat, **as directed**, top.
    - a. Front Inlet Grille: Punched louver; painted to match enclosure.
    - b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      - 1) Mill-finish aluminum.
      - 2) Anodized finish color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
      - 3) Painted to match enclosure.
    - c. Top **OR** Front, **as directed**, Outlet Grille: Punched louver; painted to match enclosure.
    - d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      - 1) Mill-finish aluminum.
      - 2) Anodized finish color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
      - 3) Painted to match enclosure.
  12. Unit Controls: Integral line-voltage thermostat with minimum range of **60 to 90 deg F (15 to 32 deg C)** **OR** low-voltage relay and control transformer for remote thermostat, **as directed**.
  13. Accessories: Integral disconnect switch, filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.
- D. Hot-Water Finned-Tube Radiators
1. Performance Ratings: Rate finned-tube radiators according to Hydronics Institute's "I=B=R Testing and Rating Standard for Finned-Tube (Commercial) Radiation."
  2. Heating Elements: Copper tubing mechanically expanded into flanged collars of evenly spaced aluminum fins resting on element supports. One tube end shall be belled.
    - a. Tube Diameter: **NPS 3/4 (DN 20) OR NPS 1 (DN 25) OR NPS 1-1/4 (DN 32)**, **as directed**.
    - b. Fin Size: **3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm)**, **as directed**.
    - c. Fin Spacing: **40 per foot (131 per meter) OR 50 per foot (164 per meter) OR 58 per foot (190 per meter)**, **as directed**.
    - d. Entering Air Temperature: **65 deg F (18 deg C)**.
    - e. Average Water Temperature: **180 deg F (82 deg C)**.
    - f. Minimum Water Velocity: **1/2 fps (0.15 m/s)**.
    - g. Entering Steam Pressure: **1 psig (6.9 kPa)**.
  3. Heating Elements: Steel tubing mechanically expanded into flanged collars of evenly spaced steel fins resting on element supports. Tube ends shall be threaded.
    - a. Tube Diameter: **NPS 1-1/4 (DN 32)**.
    - b. Fin Size: **4 by 4 inches (102 by 102 mm)**.
    - c. Fin Spacing: **52 per foot (171 per meter)**.
    - d. Entering Air Temperature: **65 deg F (18 deg C)**.
    - e. Average Water Temperature: **180 deg F (82 deg C)**.
    - f. Minimum Water Velocity: **1/2 fps (0.15 m/s)**.
    - g. Entering Steam Pressure: **1 psig (6.9 kPa)**.
  4. Element Supports: Ball-bearing cradle type to permit longitudinal movement on enclosure brackets.
  5. Front Panel: Minimum **0.0428-inch- (1.1-mm-) OR 0.0528-inch- (1.35-mm-)**, **as directed**, thick steel.
  6. Rust-Resistant Front Panel: Minimum **0.052-inch- (1.3-mm-) OR 0.064-inch- (1.6-mm-)**, **as directed**, thick, ASTM A 653/A 653M, G60 galvanized steel.

7. Wall-Mounting Back Panel: Minimum **0.0329-inch- (0.85-mm-)** thick steel, full height, with full-length channel support for front panel without exposed fasteners.
8. Floor-Mounting Pedestals: Conceal insulated piping at maximum **36-inch (914-mm)** spacing. Pedestal-mounting back panel shall be solid panel matching front panel. Provide stainless-steel escutcheon for floor openings at pedestals.
9. Support Brackets: Locate at maximum **36-inch (914-mm)** spacing to support front panel and element.
10. Finish: Baked-enamel **OR** epoxy, **as directed**, finish in manufacturer's standard **OR** custom, **as directed** color as selected.
11. Damper: Knob-operated internal damper at enclosure outlet.
12. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size **6 by 7 inches (150 by 175 mm)**, integral with enclosure.
13. Enclosure Style: Sloped **OR** Flat, **as directed**, top.
  - a. Front Inlet Grille: Punched louver; painted to match enclosure.
  - b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
    - 1) Mill-finish aluminum.
    - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
    - 3) Painted to match enclosure.
  - c. Top **OR** Front, **as directed**, Outlet Grille: Punched louver; painted to match enclosure.
  - d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
    - 1) Mill-finish aluminum.
    - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
    - 3) Painted to match enclosure.
14. Accessories: Filler sections, corners, relay sections, and splice plates all matching the enclosure and grille finishes.

#### E. Electric Convectors

1. Description: Factory-packaged units constructed according to UL 499, UL 1030, and UL 2021.
2. Heating Elements: Nickel-chromium-wire heating element enclosed in metallic sheath mechanically bonded into fins, with high-temperature cutout and sensor running the full length of element. Element supports shall eliminate thermal expansion noise.
  - a. Heat Output: 300 **OR** 500 **OR** 750 **OR** 1000 **OR** 1250 **OR** 1500 **OR** 1750 **OR** 2000 **OR** 2250 **OR** 2500, **as directed**, W.
3. Front and Top Panel: Minimum **0.0528-inch- (1.35-mm-)** **OR** **0.0677-inch- (1.7-mm-)**, **as directed** thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
4. Wall-Mounting Back and End Panels: Minimum **0.0428-inch- (1.1-mm-)** thick steel.
5. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum **36-inch (914-mm)** spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
6. Support Brackets: Locate at maximum **36-inch (914-mm)** spacing to support front panel and element.
7. Insulation: **1/2-inch- (13-mm-)** thick, fibrous glass on inside of the back of the enclosure.
8. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
9. Damper: Knob-operated internal damper.
10. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size **6 by 7 inches (150 by 175 mm)**, integral with enclosure.
11. Enclosure Style: Sloped **OR** Flat, **as directed**, top.
  - a. Front Inlet Grille: Punched louver; painted to match enclosure.
  - b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
    - 1) Mill-finish aluminum.

- 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
  - 3) Painted to match enclosure.
  - c. Top **OR** Front, **as directed**, Outlet Grille: Punched louver; painted to match enclosure.
  - d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
    - 1) Mill-finish aluminum.
    - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
    - 3) Painted to match enclosure.
  12. Unit Controls: Integral line-voltage thermostat with minimum range of **60 to 90 deg F (15 to 32 deg C)** **OR** low-voltage relay and control transformer for remote thermostat, **as directed**.
  13. Accessories: Integral disconnect switch, recessing flanges finished to match enclosure or overlapping front cover for fully recessed units, and rubber gaskets to seal cabinet at wall.
- F. Hot-Water Or Steam Convectors
1. Convector Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins and rolled into cast-iron or brass headers with inlet/outlet and air vent; steel side plates and supports. Factory-pressure-test element at minimum **100 psig (690 kPa)**.
    - a. Entering Air Temperature: **65 deg F (18 deg C)**.
    - b. Average Water Temperature: **180 deg F (82 deg C)**.
    - c. Temperature Drop: **10 deg F (5.56 deg C)** **OR** **20 deg F (11.1 deg C)** **OR** **30 deg F (16.6 deg C)**, **as directed**.
    - d. Entering Steam Pressure: **1 psig (6.9 kPa)**.
  2. Front and Top Panel: Minimum **0.0528-inch- (1.35-mm-)** **OR** **0.0677-inch- (1.7-mm-)**, **as directed**, thick steel with exposed corners rounded; removable front panels with tamper-resistant fasteners braced and reinforced for stiffness.
  3. Wall-Mounting Back and End Panels: Minimum **0.0428-inch- (1.1-mm-)** thick steel.
  4. Floor-Mounting Pedestals: Conceal conduit for power and control wiring at maximum **36-inch (914-mm)** spacing. Pedestal-mounting back panel shall be solid panel matching front panel.
  5. Support Brackets: Locate at maximum **36-inch (914-mm)** spacing to support front panel and element.
  6. Insulation: **1/2-inch- (13-mm-)** thick, fibrous glass on inside of the back of the enclosure.
  7. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed** color as selected.
  8. Damper: Knob-operated internal damper.
  9. Access Doors: Factory made, permanently hinged with tamper-resistant fastener, minimum size **6 by 7 inches (150 by 175 mm)**, integral with enclosure.
  10. Enclosure Style: Sloped **OR** Flat, **as directed**, top.
    - a. Front Inlet Grille: Punched louver; painted to match enclosure.
    - b. Front Inlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      - 1) Mill-finish aluminum.
      - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
      - 3) Painted to match enclosure.
    - c. Top **OR** Front, **as directed**, Outlet Grille: Punched louver; painted to match enclosure.
    - d. Top **OR** Front, **as directed**, Outlet Grille: Extruded-aluminum linear bar grille; pencil-proof bar spacing.
      - 1) Mill-finish aluminum.
      - 2) Anodized finish, color as selected from manufacturer's standard **OR** custom, **as directed**, colors.
      - 3) Painted to match enclosure.
- G. Flat-Pipe Steel Radiators
1. Heating Elements: Steel, welded and formed into flat, square, steel header with minimum thickness of **0.109 inches (2.76 mm)**. Include threaded piping and air vent connections.



- a. Working Pressure **56 psig** (386 kPa): **0.048 inch** (1.22 mm).
  - b. Working Pressure **85 psig** (585 kPa): **0.058 inch** (1.47 mm).
  - c. Working Pressure **128 psig** (881 kPa): **0.078 inch** (1.98 mm).
  - d. Room Air Temperature: **65 deg F** (18 deg C).
  - e. Average Water Temperature: **180 deg F** (82 deg C).
  - f. Temperature Drop: **10 deg F** (5.56 deg C) **OR 20 deg F** (11.1 deg C) **OR 30 deg F** (16.6 deg C), **as directed**.
2. Mounting: Wall brackets **OR** Floor pedestals, **as directed**, on maximum spacing of **36 inches** (914 mm).
  3. Finish: Baked-enamel finish in manufacturer's standard **OR** custom, **as directed**, color as selected.
  4. Accessories:
    - a. Steel piping covers finished to match radiator finish.
    - b. Flexible Expansion Compensation Hoses: Minimum **400-psig** (2758-kPa) working pressure, and operating temperatures from **33 to 211 deg F** (0.5 to 99.5 deg C).
      - 1) Length: **24 inches** (600 mm) **OR 36 inches** (900 mm), **as directed**.
      - 2) Minimum Diameter: Equal to connection size.

### 1.3 EXECUTION

- A. Baseboard Radiator Installation
  1. Install units level and plumb.
  2. Install baseboard radiators according to Guide 2000 - Residential Hydronic Heating.
  3. Install enclosure continuously around corners, using outside and inside corner fittings.
  4. Join sections with splice plates and filler pieces to provide continuous enclosure.
  5. Install access doors for access to valves.
  6. Install enclosure continuously from wall to wall.
  7. Terminate enclosures with manufacturer's end caps except where enclosures are indicated to extend to adjoining walls.
  8. Install valves within reach of access door provided in enclosure.
  9. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.
  10. Install piping within pedestals for freestanding units.
- B. Finned-Tube Radiator Installation
  1. Install units level and plumb.
  2. Install finned-tube radiators according to Guide 2000 - Residential Hydronic Heating.
  3. Install enclosure continuously around corners, using outside and inside corner fittings.
  4. Join sections with splice plates and filler pieces to provide continuous enclosure.
  5. Install access doors for access to valves.
  6. Install enclosure continuously from wall to wall.
  7. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.
  8. Install valves within reach of access door provided in enclosure.
  9. Install air-seal gasket between wall and recessing flanges or front cover of fully recessed unit.
  10. Install piping within pedestals for freestanding units.
- C. Convector Installation
  1. Install units level and plumb.
  2. Install valves within reach of access door provided in enclosure.
  3. Install air-seal gasketing between wall and recessing flanges or front cover of fully recessed unit.
  4. Install piping within pedestals for freestanding units.
- D. Flat-Pipe Steel Radiator Installation
  1. Install units level and plumb.

2. Install expansion compensation hoses.
3. Install piping covers.

E. Connections

1. Piping installation requirements are specified in Division 23 Section(s) "Hydronic Piping" OR "Steam And Condensate Heating Piping", **as applicable**. Drawings indicate general arrangement of piping, fittings, and specialties.
2. Connect hot-water units and components to piping according to Division 23 Section "Hydronic Piping".
  - a. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
3. Connect steam units and components to piping according to Division 23 Section "Steam And Condensate Heating Piping".
  - a. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.
4. Install control valves as required by Division 23 Section "Instrumentation And Control For Hvac".
5. Install piping adjacent to convection heating units to allow service and maintenance.
6. Ground electric convection heating units according to Division 26 Section "Grounding And Bonding For Electrical Systems".
7. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

F. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
  - a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper convection heating unit operation.
  - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
2. Remove and replace convection heating units that do not pass tests and inspections and retest as specified above.

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Task	Specification	Specification Description
23 82 29 00	01 22 16 00	No Specification Required
23 82 33 00	01 22 16 00	No Specification Required
23 82 33 00	23 82 29 00	Convection Heating Units
23 82 36 00	01 22 16 00	No Specification Required
23 82 36 00	23 82 29 00	Convection Heating Units
23 82 39 13	01 22 16 00	No Specification Required
23 82 39 13	23 55 33 00a	Unit Heaters
23 82 39 16	01 22 16 00	No Specification Required
23 82 39 16	23 55 33 00a	Unit Heaters
23 82 39 19	01 22 16 00	No Specification Required
23 82 39 19	23 55 33 00a	Unit Heaters

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## SECTION 23 84 13 23 - HUMIDIFIERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for humidifiers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following humidifiers:
  - a. Atomizing.
  - b. Steam injection.
  - c. Self-contained.
  - d. Heated pan.
  - e. Heat exchanger.

#### C. Definition

1. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

#### D. Submittals

1. Product Data: Include rated capacities, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Detail fabrication and installation of humidifiers. Include piping details, plans, elevations, sections, details of components, manifolds, and attachments to other work.
  - a. Wiring Diagrams: Power, signal, and control wiring.
3. Field quality-control test reports.
4. Operation and maintenance data.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with ARI 640, "Commercial and Industrial Humidifiers."

### 1.2 Products

#### A. Water-Pressure Atomizing Humidifiers

1. Nozzles: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel.
2. Manifold: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel piping.
3. Droplet Filter: Biocide-treated polyethylene with maximum **0.30-inch wg (75-Pa)** resistance.
4. Piping and Fittings: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel pipe and fittings.  
**OR**  
Piping and Fittings: **ASTM B 88 (ASTM B 88M)**, Type L copper pipe and wrought-copper fittings with brazed joints.
5. Water Pump: Enclosed belt-drive ceramic plunger pump with stainless-steel **OR** bronze, **as directed**, heads, and single **OR** variable, **as directed**, -speed, totally enclosed, fan-cooled motor.
6. Final Water-Filter Efficiency: Minimum 98 percent retention of suspended particles 10 **OR** 20, **as directed**, microns and larger from makeup water.

7. Final Water-Filter Pressure Drop: Maximum **2 psig (14 kPa)** at design flow when clean, and **<Insert value>** when dirty, **as directed**.
  8. Pump Controls:
    - a. Cycle **OR** Vary speed of, **as directed**, motor to satisfy humidistat.
    - b. High-pressure solenoid valve for each control zone shown on Drawings.
    - c. Building automation system interface for each control zone for start/stop and status indication and control at central workstation.
  9. Dispersion Fan:
    - a. Aluminum blade propeller fan with finger guard and single-speed motor interlocked to operate with humidifier.
    - b. Fan Mounting: Above and behind manifold on bracket integral to wall-mounting manifold.
  10. Accessories:
    - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full-modulation or cycling control.
    - b. Duct-mounting, high-limit humidistat.
    - c. Airflow switch for preventing humidifier operation without airflow.
- B. Compressed-Air Atomizing Humidifiers
1. Nozzles: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel.
  2. Manifold: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel piping.
  3. Droplet Filter: Biocide-treated polyethylene with maximum **0.30-inch wg (75-Pa)** resistance.
  4. Piping and Fittings: ASTM A 269, Type 304 **OR** 316, **as directed**, stainless-steel pipe and fittings.
  5. Compressed-Air and Water, **as directed**, Piping and Fittings: **ASTM B 88 (ASTM B 88M)**, Type L copper pipe and wrought-copper fittings with soldered joints.
  6. Final Water-Filter Efficiency: Minimum 98 percent retention of suspended particles 10 **OR** 20, **as directed**, microns and larger from makeup water.
  7. Final Water-Filter Pressure Drop: Maximum **2 psig (14 kPa)** at design flow when clean, and **<Insert value>** when dirty, **as directed**.
  8. Air and Water Solenoid Controls:
    - a. Cycle valves to satisfy humidistat.
    - b. Solenoid valves for each control zone shown on Drawings.
    - c. Building automation system interface for each control zone for start/stop and status indication and control at central workstation.
  9. Dispersion Fan:
    - a. Aluminum blade propeller fan with finger guard and single-speed motor interlocked to operate with humidifier.
    - b. Fan Mounting: Above and behind manifold on bracket integral to wall-mounting manifold.
  10. Accessories:
    - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full-modulation or cycling control.
    - b. Duct-mounting, high-limit humidistat.
    - c. Airflow switch for preventing humidifier operation without airflow.
- C. Steam-Injection Humidifiers
1. Manifold: ASTM A 666, Type 304 stainless steel, steam jacketed, **as directed**; insulated with **1/2-inch (13-mm)** fiberglass and stainless-steel jacket; and , **as directed**, extending the full width of duct or plenum with mounting brackets at ends.
  2. Discharge Nozzle and Dispersion Fan:
    - a. Steam-jacketed discharge nozzle, aluminum blade propeller fan with finger guard, and single-speed motor interlocked to operate with humidifier.
    - b. Fan Mounting: Above and behind discharge outlet on bracket integral to discharge outlet.
  3. Steam Separator: Cast iron **OR** ASTM A 666, Type 304 stainless steel, **as directed**, with separate, **as directed**, humidifier control valve.
  4. Humidifier Control Valve:



- a. Actuator: Pneumatic **OR** Electric, **as directed**, modulating with spring return.  
**OR**  
Actuator: As specified in Division 23 Section "Instrumentation And Control For Hvac".
  5. Steam Trap: Inverted-bucket type, sized for a minimum of 3 times the maximum rated condensate flow of humidifier at **1/2-psig (3.4-kPa)** inlet pressure.
  6. Accessories:
    - a. Wall **OR** Return-duct, **as directed**, -mounting humidistat.
    - b. Duct-mounting, high-limit humidistat.
    - c. Aquastat mounted on steam condensate return piping to prevent cold operation of humidifier.
    - d. In-line strainer.
    - e. Airflow switch for preventing humidifier operation without airflow.
- D. Self-Contained Humidifiers
  1. Electric-Resistance Heater Container: Cleanable, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel. Comply with UL 499.
  2. Electrode Cylinder: Replaceable plastic assembly with disposable ionic bed inserts, **as directed**. Comply with UL 499.
  3. Gas-Fired Steam Generator: Factory assembled and tested.
    - a. Standard: Fabricate and label steam generator to comply with CSA.
    - b. Maximum Steam Pressure: **10 inches wg (2488 Pa)**.
    - c. Burner Type: Natural-gas **OR** Propane, **as directed**, fired with modulating, low NOx infrared burner, minimum 82 percent efficient.
    - d. Gas Train: Safety shutoff valves, gas cock, strainer, pressure-regulating valve.
    - e. Ignition: Hot-surface ignition with flame safety system.
    - f. Combustion Chamber: Sealed with outdoor-air and flue-vent connections.
    - g. Heat-Exchanger Tank: Cleanable, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating and disposable ionic bed inserts, **as directed**.
  4. Manifold: Stainless-steel tube with integral fan to discharge vapor directly into occupied space.  
**OR**  
Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube extending across entire width of duct or plenum and equipped with mounting brackets on ends.
  5. Cabinet: Sheet metal enclosure for housing heater cylinder, electrical wiring, components, controls, and control panel. Enclosure shall include baked-enamel finish, hinged or removable access door, and threaded outlet in bottom of cabinet for drain piping.
  6. Control Panel:
    - a. Factory-wired disconnect switch.
    - b. Liquid-crystal display.
    - c. Programmable keyboard.
    - d. Set-point adjustment.
    - e. Warning signal indicating end of replaceable cylinder or ionic bed insert, **as directed**, life.
    - f. Low-voltage, control circuit.
    - g. Diagnostic, maintenance, alarm, and status features.
    - h. High-water sensor **OR** float, **as directed**, to prevent overfilling.
  7. Controls:
    - a. Microprocessor-based control system for modulating or cycling control, and start/stop and status monitoring for interface to central HVAC instrumentation and controls.
    - b. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
    - c. Field-adjustable timer to control drain cycle for flush duration and interval.
    - d. Controls shall drain tanks if no demand for humidification for more than 72 hours.
    - e. Conductivity **OR** Float, **as directed**, -type level controls.
  8. Accessories:
    - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
    - b. Duct-mounting, high-limit humidistat.
    - c. Airflow switch for preventing humidifier operation without airflow.

## E. Heated-Pan Humidifiers

1. Heat Source: Hot water **OR** Steam **OR** Electric resistance, **as directed**.
2. Comply with UL 499.
3. Pan and Heat-Exchange Piping: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating, overflow, and drain fittings. Include disposable ionic bed inserts, **as directed**.
4. Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel, duct-mounting, single- or manifold-grid connected to heated-pan housing with flexible hose and extending across width of duct or plenum. Manifold shall have mounting brackets at both ends.  
**OR**  
Manifold: Inverted, ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel U-tube with humidifier mounted directly under the duct.  
**OR**  
Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube with flexible hose to connect to humidifier, integral fan to discharge vapor directly into occupied space, and wall- or ceiling-mounting brackets.
5. Controls:
  - a. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
  - b. Field-adjustable timer to control drain cycle for flush duration and interval.
  - c. Conductivity **OR** Float, **as directed**, -type level controls.
6. Piping Specialties: Inlet strainer, control valve, and steam trap.
7. Piping Specialties: Inlet strainer and control valve.
8. Accessories:
  - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full modulation or cycling control.
  - b. Duct-mounting, high-limit humidistat.
  - c. Airflow switch for preventing humidifier operation without airflow.

## F. Heat-Exchanger Humidifiers

1. Fabricate and label steam generator to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Heat Exchanger: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless steel with corrosion-resistant coating, overflow, and drain fittings. Include disposable ionic bed inserts, **as directed**.
3. Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel, steam-jacketed, **as directed**, duct-mounting, single- or manifold-grid connected to steam generator with flexible hose and extending across width of duct or plenum. Manifold shall have mounting brackets for both ends. Insulate with 1/2-inch (13-mm) fiberglass and stainless-steel jacket extending full width of duct or plenum with mounting brackets at ends, **as directed**.  
**OR**  
Manifold: ASTM A 666, Type 304 **OR** 316, **as directed**, stainless-steel tube with flexible hose to connect to humidifier and integral fan to discharge vapor directly into occupied space. Manifold shall have wall- or ceiling-mounting brackets.
4. Controls:
  - a. Solenoid-fill and automatic drain valves to maintain water level and temper hot drain water.
  - b. Field-adjustable timer to control drain cycle for flush duration and interval.
  - c. Conductivity **OR** Float, **as directed**, -type level controls.
5. Accessories:
  - a. Humidistat: Wall **OR** Return-duct, **as directed**, -mounting, solid-state, electronic-sensor controller capable of full modulation.
  - b. Duct-mounting, high-limit humidistat.
  - c. Airflow switch for preventing humidifier operation without airflow.

### 1.3 EXECUTION

#### A. Installation

1. Install humidifiers with required clearance for service and maintenance. Maintain path, downstream from humidifiers, clear of obstructions as required by ASHRAE 62.1, **as directed**.
2. Seal humidifier manifold duct or plenum penetrations with flange.
3. Install humidifier manifolds in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."
4. Install galvanized **OR** stainless, **as directed**, -steel drain pan under each manifold mounted in duct.
  - a. Construct drain pans with connection for drain; insulated and complying with ASHRAE 62.1, **as directed**.
  - b. Connect to condensate trap and drainage piping.
  - c. Extend drain pan upstream and downstream from manifold a minimum distance recommended by manufacturer but not less than required by ASHRAE 62.1.
5. Install manifold supply piping pitched to drain condensate back to humidifier.
6. Install drip leg upstream from steam trap a minimum of **12 inches (300 mm)** tall for proper operation of trap.
7. Install steam generator level on concrete base. Concrete base is specified in Division 23 Section "Common Work Results For Hvac".
8. Concrete Bases: Anchor steam generator to concrete base.
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around full perimeter of base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - e. Cast-in-place concrete materials and placement requirements are specified in Division 31.
9. Install seismic restraints on humidifiers. Seismic restraints are specified in Division 23 Section "Vibration And Seismic Controls For Hvac Piping And Equipment".
10. Install gas-fired steam generators according to NFPA 54.

#### B. Connections

1. Piping installation requirements are specified in other Division 21. Drawings indicate general arrangement of piping, fittings, and specialties.
  - a. Install piping adjacent to humidifiers to allow service and maintenance.
  - b. Install shutoff valve, strainer, backflow preventer, and union in humidifier makeup line.
2. Install electrical devices and piping specialties furnished by manufacturer but not factory mounted.
3. Install piping from safety relief valves to nearest floor drain.
4. Connect gas piping full size to steam-generator, gas-train inlet with union. Gas piping materials and specialties are specified in Division 23 Section(s) "Facility Natural-gas Piping" OR "Facility Liquefied-petroleum Gas Piping", **as directed**.
5. Connect breeching full size to steam-generator outlet. Venting materials are specified in Division 23 Section "Breechings, Chimneys, And Stacks".
6. Connect combustion-air inlet to intake terminal using PVC piping with solvent-cemented joints. Run from boiler connection to outside and terminate adjacent to flue termination.
7. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
8. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:



- a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
  - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning units and retest as specified above.
- D. Demonstration
1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain humidifiers.

END OF SECTION 23 84 13 23

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Task	Specification	Specification Description
23 84 13 29	23 84 13 23	Humidifiers
23 84 16 33	01 22 16 00	No Specification Required
23 84 16 33	23 76 13 00	Dehumidification Units

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Task	Specification	Specification Description
25 55 00 00	23 09 00 00	HVAC Instrumentation And Controls

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Task	Specification	Specification Description
26 01 30 91	01 22 16 00	No Specification Required
26 01 50 51	01 22 16 00	No Specification Required
26 01 50 51	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 01 50 51	02 84 16 00a	Interior Lighting
26 01 50 51	02 84 16 00b	Exterior Lighting
26 01 50 52	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 01 50 52	02 84 16 00a	Interior Lighting
26 01 50 52	02 84 16 00b	Exterior Lighting
26 01 50 53	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 01 50 53	02 84 16 00a	Interior Lighting
26 01 50 53	02 84 16 00b	Exterior Lighting
26 01 50 81	02 84 16 00a	Interior Lighting

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## SECTION 26 05 00 00 - COMMON WORK RESULTS FOR ELECTRICAL

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for electrical. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Electrical equipment coordination and installation.
  - b. Sleeves for raceways and cables.
  - c. Sleeve seals.
  - d. Grout.
  - e. Common electrical installation requirements.

#### C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

#### D. Submittals

1. Product Data: For sleeve seals.

### 1.2 PRODUCTS

#### A. Sleeves For Raceways And Cables

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
  - a. Minimum Metal Thickness:
    - 1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
    - 2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

#### B. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
  - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

#### C. Grout

1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

### 1.3 EXECUTION

#### A. Common Requirements For Electrical Installation

1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

#### B. Sleeve Installation For Electrical Penetrations

1. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors **2 inches (50 mm)** above finished floor level.
7. Size pipe sleeves to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and raceway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
  - a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
11. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for **1-inch (25-mm)** annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

#### C. Sleeve-Seal Installation

1. Install to seal exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve

seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Firestopping

1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping".

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## SECTION 26 05 13 16 - CONDUCTORS AND CABLES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of conductors and cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Building wires and cables rated 600 V and less.
  - b. Connectors, splices, and terminations rated 600 V and less.
  - c. Sleeves and sleeve seals for cables.

#### C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Field quality-control test reports.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

### 1.2 PRODUCTS

#### A. Conductors And Cables

1. Aluminum and Copper, **as directed**, Conductors: Comply with NEMA WC 70.
2. Conductor Insulation: Comply with NEMA WC 70 for Types THW **OR** THHN-THWN **OR** XHHW **OR** UF **OR** USE **OR** SO, **as directed**.
3. Multiconductor Cable: Comply with NEMA WC 70 for armored cable, Type AC **OR** metal-clad cable, Type MC **OR** mineral-insulated, metal-sheathed cable, Type MI **OR** nonmetallic-sheathed cable, Type NM **OR** Type SO **OR** Type USE, **as directed**, with ground wire.

#### B. Connectors And Splices

1. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

#### C. Sleeves For Cables

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum **0.052- or 0.138-inch (1.3- or 3.5-mm)** thickness as indicated and of length to suit application.
4. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".



#### D. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
  - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
  - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

### 1.3 EXECUTION

#### A. Conductor Material Applications

1. Feeders: Copper **OR** Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger, **as directed**. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
2. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

#### B. Conductor Insulation And Multiconductor Cable Applications And Wiring Methods

1. Service Entrance: Type THHN-THWN, single conductors in raceway **OR** Type XHHW, single conductors in raceway **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Type SE or USE multiconductor cable, **as directed**.
2. Exposed Feeders: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
3. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
4. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway **OR** Underground feeder cable, Type UF, **as directed**.
5. Feeders Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.
6. Feeders in Cable Tray: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
7. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
8. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI **OR** Nonmetallic-sheathed cable, Type NM, **as directed**.
9. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway **OR** Underground branch-circuit cable, Type UF, **as directed**.
10. Branch Circuits Installed below Raised Flooring: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.

11. Branch Circuits in Cable Tray: Type THHN-THWN, single conductors in raceway **OR** Armored cable, Type AC **OR** Metal-clad cable, Type MC **OR** Mineral-insulated, metal-sheathed cable, Type MI, **as directed**.
12. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
13. Class 1 Control Circuits: Type THHN-THWN, in raceway.
14. Class 2 Control Circuits: Type THHN-THWN, in raceway **OR** Power-limited cable, concealed in building finishes **OR** Power-limited tray cable, in cable tray, **as directed**.

C. Installation Of Conductors And Cables

1. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
2. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
3. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
4. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
5. Support cables according to Division 26 Section "Hangers And Supports For Electrical Systems".
6. Identify and color-code conductors and cables according to Division 26 Section "Identification For Electrical Systems".
7. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
8. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
  - a. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
9. Wiring at Outlets: Install conductor at each outlet, with at least **6 inches (150 mm) OR 12 inches (300 mm), as directed**, of slack.

D. Sleeve Installation For Electrical Penetrations

1. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
  - a. For sleeve rectangle perimeter less than **50 inches (1270 mm)** and no side greater than **16 inches (400 mm)**, thickness shall be **0.052 inch (1.3 mm)**.
  - b. For sleeve rectangle perimeter equal to, or greater than, **50 inches (1270 mm)** and 1 or more sides equal to, or greater than, **16 inches (400 mm)**, thickness shall be **0.138 inch (3.5 mm)**.
5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both wall surfaces.
7. Extend sleeves installed in floors **2 inches (50 mm)** above finished floor level.
8. Size pipe sleeves to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance, **as directed**.
9. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies, **as directed**.
10. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants".



11. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping".
12. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
13. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
14. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

E. Sleeve-Seal Installation

1. Install to seal underground exterior-wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

F. Firestopping

1. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Penetration Firestopping".

G. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
  - a. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors, and conductors feeding the following critical equipment and services, **as directed**, for compliance with requirements.
  - b. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - c. Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.
    - 1) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each splice 11 months after date of Final Completion.
    - 2) Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - 3) Record of Infrared Scanning: Prepare a certified report that identifies splices checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
3. Test Reports: Prepare a written report to record the following:
  - a. Test procedures used.
  - b. Test results that comply with requirements.
  - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
4. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 13 16

## SECTION 26 05 13 16a - UNDERCARPET CABLES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of undercarpet cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Undercarpet cable and service fittings for branch circuits.
  - b. Undercarpet cable and service fittings for communication and data transmission.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details of components, and attachments to other work.
  - a. Indicate cable types, accessories, and transition boxes.
  - b. Indicate proposed layering of cables, cable dimensions, and installation requirements.
3. Field quality-control test reports.
4. Operation and maintenance data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NEMA UC 2, "Undercarpet Power Distribution Systems" and with NFPA 70.

### 1.2 PRODUCTS

#### A. Power Distribution Cable

1. Cable: Factory laminated and complying with NEMA UC 2; three-piece assembly including bottom shield, conductor assembly, and top shield.
  - a. Bottom Shield: Abrasion resistant, nonmetallic **OR** Metallic, **as directed**.
  - b. Conductor Assembly: Two **OR** Three **OR** Four, **as directed**,-wire branch circuit with insulated ground, **as directed**.
  - c. Top Shield: Copper or copper alloy.
2. Current Rating: 20 **OR** 30 **OR** 20 and 30, **as directed**, A.

#### B. Communication And Data Cable

1. Category 5e Communication and Data Cable: Extruded-vinyl jacket over 4 unshielded, twisted pairs, No. 24 AWG, copper; complying with TIA/EIA 568-B; and tested to 300-lb (136-kg) rollover test.

#### C. Pedestals

1. Description: Manufacturer's standard low **OR** regular, **as directed**,-profile type, single **OR** two **OR** three, **as directed**, gang with single **OR** duplex, **as directed**, receptacles and Category 5e modular connectors, **as directed**.
  - a. Pedestal Colors: As selected from manufacturer's full range.

#### D. Power Cable Transition Unit



1. Description: Interface transition unit, with junction box, for connecting three-, four-, or five-conductor, flat-conductor cable to building wiring system.

E. Communication And Data Cable Transition Unit

1. Description: Category 5 transition termination circuit board in wall-mounted box to convert round incoming cable to outgoing flat-undercarpet cable.

### 1.3 EXECUTION

A. Installation

1. Do not begin installation until heavy construction is completed and wheeled traffic is no longer a threat.
2. Do not stack cables in circulation routes.
3. Limit total installed height to 0.09 inch (2.29 mm).
4. Install cables in proper order with power-transmission cable first, followed by telephone cable and then data cable. Cross cables at 90-degree angles.
5. Install undercarpet cables and accessories using special tools as recommended by undercarpet cable manufacturer.

B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect undercarpet cable and components to branch circuits and to ground as indicated and instructed by manufacturer.

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
  - a. Branch-Circuit Cables: After cables have been installed and energized, perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - b. Communication and Data Cables: After cables have been installed and connected between telecommunications outlet and system cross-connect panel, test each cable according to TIA/EIA TSB67. Certify compliance with test parameters.
3. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 13 16a

## SECTION 26 05 13 16b - MEDIUM-VOLTAGE CABLES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of medium-voltage cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes cables and related splices, terminations, and accessories for medium-voltage electrical distribution systems.

#### C. Definitions

1. NETA ATS: Acceptance Testing Specification.

#### D. Submittals

1. Product Data: For each type of cable indicated. Include splices and terminations for cables and cable accessories.
2. Field quality-control test reports.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C2 and NFPA 70.

### 1.2 PRODUCTS

#### A. Cables

1. Cable Type: MV90 **OR** MV105, **as directed**.
2. Comply with UL 1072, AEIC CS 8, ICEA S-93-639, and ICEA S-97-682, **OR** ICEA S-94-649, **as directed**.
3. Conductor: Copper **OR** Aluminum, **as directed**.
4. Conductor Stranding: Compact round, concentric lay, Class B) **OR** Concentric lay, Class B, **as directed**.
5. Strand Filling: Conductor interstices are filled with impermeable compound.
6. Conductor Insulation: Crosslinked polyethylene **OR** Ethylene-propylene rubber, **as directed**.
  - a. Voltage Rating: 5 **OR** 8 **OR** 15 **OR** 25 **OR** 35, **as directed**, kV.
  - b. Insulation Thickness: 100 **OR** 133, **as directed**, percent insulation level.
7. Shielding: Copper tape **OR** Solid copper wires, **as directed**, helically applied over semiconducting insulation shield.
8. Shielding and Jacket: Corrugated copper drain wires embedded in extruded, chlorinated, polyethylene jacket.
9. Three-Conductor Cable Assembly: Three insulated, shielded conductors cabled together with ground conductors, **as directed**.
  - a. Circuit Identification: Color-coded tape (black, red, blue) under the metallic shielding.
10. Cable Armor: Interlocked aluminum **OR** Interlocked galvanized steel **OR** Corrugated aluminum tube, **as directed**, applied over cable.
11. Cable Jacket: Sunlight-resistant PVC **OR** Chlorosulfonated polyethylene, CPE, **as directed**.

#### B. Splice Kits



1. Connectors and Splice Kits: Comply with IEEE 404; type as recommended by cable or splicing kit manufacturer for the application.
2. Splicing Products: As recommended, in writing, by splicing kit manufacturer for specific sizes, ratings, and configurations of cable conductors. Include all components required for complete splice, with detailed instructions.
  - a. Combination tape and cold-shrink-rubber sleeve kit with re-jacketing by cast-epoxy-resin encasement or other waterproof, abrasion-resistant material.
  - b. Heat-shrink splicing kit of uniform, cross-section, polymeric construction with outer heat-shrink jacket.
  - c. Premolded, cold-shrink-rubber, in-line splicing kit.
  - d. Premolded EPDM splicing body kit with cable joint sealed by interference fit of mating parts and cable.

C. Solid Terminations

1. Multiconductor Cable Sheath Seals: Type recommended by seal manufacturer for type of cable and installation conditions, including orientation.
  - a. Compound-filled, cast-metal body, metal-clad cable terminator for metal-clad cable with **OR** without, **as directed**, external plastic jacket.
  - b. Cold-shrink sheath seal kit with preformed sleeve openings sized for cable and insulated conductors.
  - c. Heat-shrink sheath seal kit with phase- and ground-conductor re-jacketing tubes, cable-end sealing boot, and sealing plugs for unused ground-wire openings in boot.
  - d. Cast-epoxy-resin sheath seal kit with wraparound mold and packaged, two-part, epoxy-resin casting material.
2. Shielded-Cable Terminations: Comply with the following classes of IEEE 48. Insulation class is equivalent to that of cable. Include shield ground strap for shielded cable terminations.
  - a. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief tube; multiple, molded-silicone rubber, insulator modules; shield ground strap; and compression-type connector.
  - b. Class 1 Terminations: Heat-shrink type with heat-shrink inner stress control and outer nontracking tubes; multiple, molded, nontracking skirt modules; and compression-type connector.
  - c. Class 1 Terminations: Modular type, furnished as a kit, with stress-relief shield terminator; multiple-wet-process, porcelain, insulator modules; shield ground strap; and compression-type connector.
  - d. Class 1 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, compression-type connector, and end seal.
  - e. Class 2 Terminations, Indoors: Kit with stress-relief tube, nontracking insulator tube, shield ground strap, and compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.
  - f. Class 3 Terminations: Kit with stress cone and compression-type connector.
3. Nonshielded-Cable Terminations: Kit with compression-type connector. Include silicone-rubber tape, cold-shrink-rubber sleeve, or heat-shrink plastic-sleeve moisture seal for end of insulation whether or not supplied with kits.

D. Separable Insulated Connectors

1. Description: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators and with matching, stationary, plug-in, dead-front terminals designed for cable voltage and for sealing against moisture.
2. Terminations at Distribution Points: Modular type, consisting of terminators installed on cables and modular, dead-front, terminal junctions for interconnecting cables.
3. Load-Break Cable Terminators: Elbow-type units with 200-A load make/break and continuous-current rating; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

4. Dead-Break Cable Terminators: Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.
  5. Dead-Front Terminal Junctions: Modular bracket-mounted groups of dead-front stationary terminals that mate and match with above cable terminators. Two-, three-, or four-terminal units as indicated, with fully rated, insulated, watertight conductor connection between terminals and complete with grounding lug, manufacturer's standard accessory stands, stainless-steel mounting brackets, and attaching hardware.
    - a. Protective Cap: Insulating, electrostatic-shielding, water-sealing cap with drain wire.
    - b. Portable Feed-Through Accessory: Two-terminal, dead-front junction arranged for removable mounting on accessory stand of stationary terminal junction.
    - c. Grounding Kit: Jumpered elbows, portable feed-through accessory units, protective caps, test rods suitable for concurrently grounding three phases of feeders, and carrying case.
    - d. Standoff Insulator: Portable, single dead-front terminal for removable mounting on accessory stand of stationary terminal junction. Insulators suitable for fully insulated isolation of energized cable-elbow terminator.
  6. Test-Point Fault Indicators: Applicable current-trip ratings and arranged for installation in test points of load-break separable connectors, and complete with self-resetting indicators capable of being installed with shotgun hot stick and tested with test tool.
  7. Tool Set: Shotgun hot stick with energized terminal indicator, fault-indicator test tool, and carrying case.
- E. Arc-Proofing Materials
1. Tape for First Course on Metal Objects: **10-mil- (250-micrometer-)** thick, corrosion-protective, moisture-resistant, PVC pipe-wrapping tape.
  2. Arc-Proofing Tape: Fireproof tape, flexible, conformable, intumescent to **0.3 inch (8 mm)** thick, compatible with cable jacket.
  3. Glass-Cloth Tape: Pressure-sensitive adhesive type, **1/2 inch (13 mm)** wide.
- F. Fault Indicators
1. Indicators: Automatically **OR** Manually, **as directed**, reset fault indicator with inrush restraint feature, arranged to clamp to cable sheath and provide a display after a fault has occurred in cable. Instrument shall not be affected by heat, moisture, and corrosive conditions and shall be recommended by manufacturer for installation conditions.
  2. Resetting Tool: Designed for use with fault indicators, with moisture-resistant storage and carrying case.
- G. Source Quality Control
1. Test and inspect cables according to ICEA S-97-682 **OR** ICEA S-94-649, **as directed**, before shipping.
  2. Test strand-filled cables for water-penetration resistance according to ICEA T-31-610, using a test pressure of **5 psig (35 kPa)**.

### 1.3 EXECUTION

- A. Installation
1. Install cables according to IEEE 576.
  2. Pull Conductors: Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
    - a. Where necessary, use manufacturer-approved pulling compound or lubricant that will not deteriorate conductor or insulation.
    - b. Use pulling means, including fish tape, cable, rope, and basket-weave cable grips that will not damage cables and raceways. Do not use rope hitches for pulling attachment to cable.

3. Install exposed cables parallel and perpendicular to surfaces of exposed structural members and follow surface contours where possible.
4. Support cables according to Division 26 Section "Common Work Results For Electrical".
5. Install direct-buried cables on leveled and tamped bed of **3-inch- (75-mm-)** thick, clean sand. Separate cables crossing other cables or piping by a minimum of **4 inches (100 mm)** of tamped earth. Install permanent markers at ends of cable runs, changes in direction, and buried splices.
6. Install "buried-cable" warning tape **12 inches (305 mm)** above cables.
7. In manholes, handholes, pull boxes, junction boxes, and cable vaults, train cables around walls by the longest route from entry to exit and support cables at intervals adequate to prevent sag.
8. Install cable splices at pull points and elsewhere as indicated; use standard kits.
9. Install terminations at ends of conductors and seal multiconductor cable ends with standard kits.
10. Install separable insulated-connector components as follows:
  - a. Protective Cap: At each terminal junction, with one on each terminal to which no feeder is indicated to be connected.
  - b. Portable Feed-Through Accessory: Three.
  - c. Standoff Insulator: Three.
11. Arc Proofing: Unless otherwise indicated, arc proof medium-voltage cable at locations not protected by conduit, cable tray, direct burial, or termination materials. In addition to arc-proofing tape manufacturer's written instructions, apply arc proofing as follows:
  - a. Clean cable sheath.
  - b. Wrap metallic cable components with **10-mil (250-micrometer)** pipe-wrapping tape.
  - c. Smooth surface contours with electrical insulation putty.
  - d. Apply arc-proofing tape in one half-lapped layer with coated side toward cable.
  - e. Band arc-proofing tape with **1-inch- (25-mm-)** wide bands of half-lapped, adhesive, glass-cloth tape **2 inches (50 mm)** o.c.
12. Seal around cables passing through fire-rated elements according to Division 07 Section "Penetration Firestopping".
13. Install fault indicators on each phase where indicated.
14. Ground shields of shielded cable at terminations, splices, and separable insulated connectors. Ground metal bodies of terminators, splices, cable and separable insulated-connector fittings, and hardware.
15. Identify cables according to Division 26 Section "Identification For Electrical Systems".

**B. Field Quality Control**

1. Perform the following field tests and inspections and prepare test reports:
  - a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
  - b. After installing medium-voltage cables and before electrical circuitry has been energized, test for compliance with requirements.
2. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 26 05 13 16b

## SECTION 26 05 19 13 - UNDERFLOOR RACEWAYS FOR ELECTRICAL SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of underfloor raceways for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Flat-top, single-channel, underfloor raceways.
  - b. Flat-top, multichannel, underfloor raceways.
  - c. Flush, flat-top underfloor raceways.
  - d. Cellular metal underfloor raceways.
  - e. Trench-type underfloor raceways.
  - f. Electrical connection components for precast concrete, hollow-core, floor decks.
  - g. Electrical connection components for electrified cellular steel floor decks.
  - h. Service fittings.

#### C. Definitions

1. Flush Outlet: Underfloor raceway outlet installed so the top of the fixed portions of the receptacles, jacks, and connector assemblies is located approximately at the surface of the floor or floor covering, and with the bodies of connected plugs exposed above the surface of the floor.
2. Flush Underfloor Raceway: Rectangular cross-section, flat-top raceway installed with the top of the raceway flush with the surface of the concrete in which it is embedded.
3. Header Raceway: Rectangular cross-section, single-channel or multichannel, underfloor raceway arranged as feeder raceway to bring wires and cables to service raceways from panelboards and communication terminal components.
4. Recessed Outlet: Underfloor raceway outlet installed with the top of the fixed portion of the connector assemblies located below the surface of the floor or floor covering and arranged to receive plug connectors with the bodies of the plugs concealed below the floor level.
5. Service Raceway: Underfloor distribution raceway providing direct connection to service fittings using preset or afterset inserts.
6. Trench Header: Trench-type raceway arranged as feeder raceway to bring wires and cables to service raceways from panelboards and communication terminal equipment.
7. Underfloor Raceway: A conduit, duct, or cell assembly, or trench located within the floor material or with its top at the floor surface.

#### D. Submittals

1. Product Data: For underfloor raceway components, fittings, and accessories.
2. Shop Drawings: For underfloor raceways. Include floor plans, assembly drawings, sections, and details.
  - a. Identify components and accessories such as expansion-joint assemblies, straight raceway lengths, preset and afterset inserts, and service fittings.
  - b. Provide dimensions locating raceway header and distribution elements. Include spacing between preset inserts and between preset inserts and ends of duct runs, walls, columns, junction boxes, and header duct connections.
  - c. Show connections between raceway elements and relationships between components and adjacent structural and architectural elements including slab reinforcement, floor finish work, permanent partitions, architectural module lines, and pretensioning or post-tensioning components.

- d. Indicate height of preset inserts, junction boxes, and raceways coordinated with depth of concrete slab and floor fill.
- e. Indicate thickening of slabs where required for adequate encasement of raceway components.
- f. Document coordination of exposed components with floor-covering materials to ensure that fittings and trim are suitable for indicated floor-covering material.
- g. Revise locations from those indicated in the Contract Documents, as required to suit field conditions and to ensure a functioning layout. Identify proposed deviations from the Contract Documents.
- h. Show details of connections and terminations of underfloor raceways at panelboards and communication terminal equipment in equipment rooms, wire closets, and similar spaces.
- i. Identify those cells of cellular floor deck that are to be connected and fitted for the following underfloor distribution:
  - 1) Power.
  - 2) Voice.
  - 3) Data.
  - 4) Signal.
  - 5) Communications.
- 3. Samples: For typical underfloor raceway products, in specified finish, including the following:
  - a. Service fittings and flush and recessed outlet and junction-box covers.
  - b. A section of each service raceway configuration with specified preset insert and service fitting installed.
  - c. A junction box of each size and type for use with underfloor raceway.
  - d. A section of each header raceway configuration, complete with provisions for connection with service raceway.
  - e. A section of trench-type raceway, complete with cover and required trim.
  - f. A junction box of each size and type, complete with cover and trim.
- 4. Operation and Maintenance Data: For underfloor raceways, to include in emergency, operation, and maintenance manuals. Include the following:
  - a. Manufacturer's written instructions for locating preset inserts and for installing afterset inserts.

#### E. Quality Assurance

- 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 2. Comply with NFPA 70.

## 1.2 PRODUCTS

### A. Flat-Top, Single-Channel, Underfloor Raceways

- 1. Description:
  - a. Material: Steel.
  - b. Cross-Section Shape: Rectangular.
  - c. Number of Levels: One **OR** Two, **as directed**.
  - d. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a **2-inch- (50-mm-)** minimum bending radius for communication cables.
- 2. Service Raceways: Fitted with preset inserts.
  - a. Nominal Raceway Dimensions:
    - 1) Depth: **1-1/2 inches (38 mm)**.
    - 2) Power Service Raceway Width: **3-1/2 inches (90 mm)**.
    - 3) Communication Service Raceway Width: **3-1/2 inches (90 mm) OR 6-1/2 inches (165 mm), as directed**.

- b. Number of Single-Channel Raceways per Run: One **OR** Two **OR** Three **OR** Four **OR** Five, **as directed**, unless otherwise indicated.
    - c. Preset Inserts: Rectangular **OR** Round, **as directed**.
      - 1) Spacing: 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed**, o.c.
      - 2) Size: Rectangular dimensions as required to accommodate mounting and connection of flush-mounted, duplex receptacle or dual communication-jack or connector service fitting.
      - 3) Size: 2 inches (50 mm) in diameter.
      - 4) Equip each insert with a disposable cover and select insert height so cover is 1/8 inch (3 mm) below surface of concrete.
      - 5) Arrange insert for optional attachment of flush-, surface-, or wiring- extension service fitting to replace disposable cover.
  - 3. Header Raceways: Single channel, without preset inserts (blank raceway).
    - a. Nominal Raceway Dimensions:
      - 1) Depth: 1-1/2 inches (38 mm).
      - 2) Power Header Raceway Width: 3-1/2 inches (90 mm).
      - 3) Communication Header Raceway Width: 3-1/2 inches (90 mm) **OR** 6-1/2 inches (165 mm), **as directed**.
    - b. Arrangement: In same plane as **OR** Below, **as directed**, service raceways.
    - c. Connections: Arranged to connect with service raceways at single-level **OR** two-level, **as directed**, junction boxes.
- B. Flat-Top, Multichannel, Underfloor Raceways
- 1. Description:
    - a. Material: Steel.
    - b. Cross-Section Shape: Rectangular.
    - c. Number of Longitudinal Channels: Two **OR** Three **OR** Four, **as directed**, separated by steel wall(s).
    - d. Number of Levels: One **OR** Two, **as directed**.
    - e. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a 2-inch- (50-mm-) minimum bending radius for communication cables.
  - 2. Service Raceways: Fitted with preset inserts.
    - a. Nominal Raceway Dimensions:
      - 1) Depth: 1-3/8 inches (35 mm).
      - 2) Power Service Channel Width: 3-1/2 inches (90 mm) **OR** 4-3/8-inches (111 mm), **as directed**.
      - 3) Communication Service Channel Width: 3-1/2 inches (90 mm) **OR** 4 inches (102 mm) **OR** 6-1/2 inches (165 mm), **as directed**.
    - b. Preset Inserts:
      - 1) Spacing: 24 inches (600 mm) **OR** 12 inches (300 mm), **as directed**, o.c.
      - 2) Size: Dimensions as required to accommodate mounting and connection of flush- and surface-mounted, single- and multiple-system service fittings or to connect to wiring extensions for feeding wall outlets for power **OR** communications **OR** power and communications, **as directed**.
      - 3) Equip each insert with a disposable cover arranged for installation with top 1/8 inch (3 mm) below surface of concrete.
      - 4) Arrange inserts for optional attachment of flush-, surface-, or wiring-extension service fitting to replace disposable cover. Arrange brackets, mountings, barriers, and floor access covers to support, isolate, and provide access to flush or surface outlet-mounting connector, jack, and receptacle devices.
  - 3. Header Raceways: Multichannel, without preset inserts (blank raceway).
    - a. Nominal Raceway Dimensions:
      - 1) Header Raceway Depth: Same as service raceways **OR** 2-1/2 inches (64 mm) **OR** 2-3/4 inches (70 mm) **OR** 3 inches (76 mm) **OR** 3-1/2 inches (90 mm), **as directed**.



- 2) Power Header Channel Width: **3-1/2 inches (90 mm) OR 4-3/8-inches (111 mm), as directed.**
- 3) Communication Header Channel Width: **3-1/2 inches (90 mm) OR 4 inches (102 mm) OR 6-1/2 inches (165 mm), as directed.**
- b. Arrangement: In same plane as **OR Below, as directed**, service raceways.
- c. Connections: Arranged to connect with service raceways at single-level **OR** two-level, **as directed**, junction boxes.

C. Flush, Flat-Top Underfloor Raceways

- 1. Description:
  - a. Material: Steel.
  - b. Cross-Section Shape: Rectangular, single channel and multichannel, separated by steel wall(s).
  - c. Listed and labeled for installation with top flush with concrete floor.
  - d. Number of Levels: One.
- 2. Service Raceways: Fitted with preset inserts.
  - a. Number of Longitudinal Channels per Multichannel Raceway: Two **OR** Three, **as directed.**
  - b. Number of Single-Channel Raceways per Run: One **OR** Two **OR** Three, **as directed**, unless otherwise indicated.
  - c. Nominal Channel Dimensions: **3 inches (76 mm)** wide by **1-1/4 inches (32 mm)** deep.
  - d. Preset Inserts: Threaded opening with removable steel plug that is flush with top of raceway when screwed in place.
    - 1) Spacing: **24 inches (600 mm) OR 12 inches (300 mm), as directed**, o.c., full length of each service raceway.
    - 2) Arrangement: Stagger insert locations on parallel raceways or channels to accommodate placement of adjacent service fittings.
    - 3) Size: **1-5/8-inch (41-mm)** diameter.
- 3. Header Raceways: Raceways same as service raceways except without preset inserts (blank raceway).
  - a. Nominal Channel Dimensions: Same as service raceways.
  - b. Arrangement: In same plane as service raceways.
  - c. Connections: Arranged to connect with service raceways at junction boxes.

D. Cellular Metal Underfloor Raceways

- 1. Service Raceways: Fitted with preset inserts.
  - a. Material: Steel.
  - b. Number of Longitudinal Cells: Three, separated by steel walls.
  - c. Nominal Dimensions of Cells:
    - 1) Overall Depth: **1-1/4 inches (32 mm)** unless otherwise indicated.
    - 2) Cross-Sectional Area of Cells: Power cells: **5-1/2 sq. in. (35.5 sq. cm);** communication system cells: **16 sq. in. (103 sq. cm).**
  - d. Minimum Bending Radius for Communication Cables: Combination of raceways, fittings, inserts, junction boxes, service fittings, and mounting and connection arrangements for wiring devices and jacks shall provide a **2-inch- (50-mm-)** minimum bending radius for communication cables.
  - e. Preset Inserts: Rectangular-shaped metal housing assemblies arranged to provide electrical outlet access to each cell of each raceway designated for service raceway use. Inserts shall be provided throughout the entire length of each such raceway.
    - 1) Spacing: **30 inches (762 mm) OR 24 inches (600 mm) OR 12 inches (300 mm), as directed**, o.c.
    - 2) Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-system service fitting.
    - 3) Include mounting and connecting provisions for a surface, single- or multiple-system service fitting.



- 4) Include connecting provisions for a wiring-extension service fitting to feed wall outlets.
  - 5) Equip each insert with a disposable cover plate arranged for installation with top **1/8 inch (3 mm)** below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable top.
2. Header Assembly: A junction box and raceway arrangement arranged to feed wires and cables to service raceways.
- a. Three-compartment junction box connecting blank, multicell cellular header raceway (no inserts) with cellular service raceways.
    - 1) Arrange junction box in the center of a **60-inch (152-cm)** length of header raceway.
    - 2) Cellular header raceway shall have same dimensions as service raceways.
    - 3) Provide capability for service raceways to be run in both directions from intersection with header raceway.
  - b. Three-compartment junction box preassembled with blank, flat-top, multichannel header raceway (no inserts) and fitted to connect with cellular service raceway at right angles to header raceway.
    - 1) Arrange junction box in the center of a **60-inch (152-cm)** length of header raceway.
    - 2) Provide capability for service raceways to be run in both directions from intersection with header raceway.
- E. Trench-Type Underfloor Raceways
1. Trench: Steel, shop or factory welded and fabricated to indicated sizes. Include the following features:
    - a. Slab Depth Adjustment: Minimum of minus **1/8 inch (3 mm)** to plus **5/8 inch (16 mm)** before and during concrete placement.
    - b. Cover Supports: Height adjustable, with leveling screws to rigidly support cover assembly.
    - c. Screed Strip: Extruded aluminum along both edges at proper elevation without requiring shim material.
    - d. Trim Strip: Select to accommodate floor finish material.
    - e. Partitions: Arranged to separate channels and isolate wiring of different systems.
    - f. Grommets openings in active floor cells or service raceways.
    - g. Manufacturer's standard corrosion-resistant finish, applied after fabrication.
  2. Cover Plates: Removable, steel plates, **1/4 inch (6 mm)** thick, each weighing **60 lb (27 kg)** or less with full gasket attached to side units. Fabricate intermediate supports to limit unsupported spans to **15 inches (380 mm)** or less. Fabricate covers with appropriate depth recess to receive indicated floor finish.
- F. Electrical Connection Components For Cellular Steel Floor Deck
1. Preset Inserts: Rectangular metal-housing assemblies.
    - a. Spacing: **30 inches (762 mm) OR 24 inches (600 mm) OR 12 inches (300 mm)**, as **directed**, o.c.
    - b. Size: As required to provide electrical outlet access to each cell of each group of three cells that is designated for electrical service raceway use.
    - c. Equip each insert with a disposable cover arranged for installation with top **1/8 inch (3 mm)** below surface of concrete. Arrange insert to receive a flush-, recessed-, or wiring-extension service fitting to replace disposable cover.
    - d. Include housing and connecting provisions for a flush or recessed, single-, double-, or triple-system service fitting.
    - e. Include mounting and connecting provisions for a surface, single-, double-, or triple-system service fitting.
    - f. Include connecting provisions for a wiring-extension service fitting to feed wall outlets.
- G. Electrical Connection Components For Cellular Concrete Floor Deck
1. Afterset Inserts: Round metal-nipple assembly with internal and external threading, arranged to screw into plug driven into **1-7/8-inch (48-mm)** hole drilled through floor fill, where present, and deck-cell wall into floor raceway cell.



- a. Inserts shall be compatible with floor-mounting service fittings.
  - b. Inserts shall provide wiring path from cell to power **OR** communication **OR** power and communication, **as directed**, wall and ceiling outlets.
  - c. Inserts shall provide wiring path from cell to header raceway.
- H. Supports, Fittings, And Hardware
  - 1. Supports, fittings, and hardware shall be compatible with raceway and outlet system and shall be listed for use with raceway systems and components specified.
  - 2. Supports: Adjustable for height and arranged to maintain alignment and spacing of raceways during concrete placement. Include hold-down straps.
  - 3. Raceway Fittings: Couplings, expansion-joint sleeves, cross-under offsets, vertical and horizontal elbows, grounding screws, adapters, end caps, and other fittings suitable for use with basic components to form a complete installation.
- I. Junction Boxes
  - 1. Description: Manufacturer's standard enclosure for indicated type, quantity, arrangement, and configuration of raceways at each raceway junction, intersection, and access location. Include the following accessories and features:
    - a. Mounting brackets.
    - b. Escutcheons and holders to accommodate surrounding floor covering.
    - c. Means for leveling and height adjustment more than **3/8 inch (10 mm)** before and after concrete is placed.
    - d. Raceway Openings: For underfloor raceways and conduits arranged to accommodate raceway layout.
    - e. Covers shall have appropriate depth recess to receive specific floor finish material.
    - f. Partitions to separate wiring of different systems.
- J. Service Fittings
  - 1. Exposed Parts Finish: Brass **OR** Brushed Aluminum, **as directed**.
  - 2. Flush, Single-System Service Fitting for Round Inserts: Include mounting and cover to support and provide access to single connector, jack, or receptacle device; mounted flush with floor within body of insert.
    - a. Connector, Jack, and Receptacle Devices: Single modular type; complying with Division 26 Section(s) "Wiring Devices" AND Division 27 Section(s) "Communications Horizontal Cabling".
    - b. Power Receptacle Outlet: Suitable for 20-A device.
  - 3. Flush, Single- or Multiple-System Service Fitting for Rectangular Inserts: Include mounting, hinged cover, and trim to support and provide access to connector, jack, or receptacle devices mounted flush with floor within insert.
    - a. Connector, Jack, and Receptacle Devices: Modular type; complying with Division 26 Section(s) "Wiring Devices" AND Division 27 Section(s) "Communications Horizontal Cabling".
    - b. Power Receptacle Rating: 20 A, 120 V unless otherwise indicated.
  - 4. Recess-Mounted Service Fitting: Modular fittings compatible with preset inserts and shall include covers; provisions for receptacles, jacks, and connectors; and associated device plates for indicated systems. Include hinged flush handhole covers with recessed depth to match thickness of floor finish material. Provide for internally mounted receptacle- and communication-jack and connector assemblies complying with requirements in Division 26 Section(s) "Wiring Devices" AND Division 27 Section(s) "Communications Horizontal Cabling".
    - a. Duplex receptacle.
    - b. Duplex telephone-data jacks.
    - c. Double duplex receptacles.
    - d. Duplex receptacle and duplex telephone-data jacks.
    - e. Double duplex telephone-data jacks, Category 5 **OR** Category 5e **OR** Category 6, **as directed**.

- f. Fiber-optic cable connector.
5. Surface-Mounted Service Fitting: Modular pedestal type, with locking attachment matched to insert floor opening.
  - a. Power-outlet, double-faced, surface-mounted unit for duplex receptacle on both sides.
  - b. Power-outlet, single-faced, surface-mounted unit for duplex receptacle on one side.
  - c. Communication-outlet, double-faced, surface-mounted unit.
    - 1) Include bushed openings on both sides; **1-inch (25-mm)** minimum diameter; insulated with nonconducting material.
    - 2) Include provisions for modular dual fiber-optic connector assembly on both sides.
    - 3) Include provisions for modular dual jack-connector assembly, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**, on both sides.
  - d. Communication-outlet, single-faced, surface-mounted unit with bushed opening on one side; **1-inch (25-mm)** minimum diameter; insulated with nonconducting material.
  - e. Combination surface-mounted unit for duplex receptacle on one side and with communication cable connection provision on opposite side.
    - 1) Communication Side: Include bushed opening; **1-inch (25-mm)** minimum diameter; insulated with nonconducting material.
    - 2) Communication Side: Include provisions for modular dual fiber-optic connector assembly.
    - 3) Communication Side: Include provisions for modular dual jack-connector assembly, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**.
6. Flush-Mounted Service Fittings: Modular fittings compatible with preset inserts and shall include covers, provisions for receptacles jacks and connector assemblies and wiring extensions to wall-mounted outlets, and associated device plates for indicated systems. Include flush handhole covers, recessed to suit floor finish material. Internally mounted, modular, receptacle, jack and connector assemblies shall comply with requirements in Division 26 Section(s) "Wiring Devices" AND Division 27 Section(s) "Communications Horizontal Cabling".
  - a. Duplex convenience receptacle.
  - b. Duplex telephone-data outlets.
  - c. Double duplex convenience receptacles.
  - d. Duplex convenience receptacle and duplex telephone-data outlets.
  - e. Double duplex telephone-data outlets.
  - f. Duplex communication jack, rated for Category 5 **OR** Category 5e **OR** Category 6, **as directed**.
  - g. Duplex fiber-optic communication connector.
  - h. Wiring-Extension Service Fittings: Arrangement of brackets and mountings to support, and provide access to wiring or cabling of a cell, and to connect the cable or raceway that extends the system to an individual wall outlet. Provide for connection of FMC **OR** ENT **OR** Type MC cable, **as directed**, for power extensions, and FMC **OR** ENT **OR** optical fiber/communication cable raceway, **as directed**, for communication system extensions.

### 1.3 EXECUTION

- A. Installation
  1. Install raceways aligned and leveled and, unless otherwise indicated, parallel or perpendicular to building walls.
  2. Provide a concrete base for support of cellular metal raceway.
  3. Arrange supports to attain proper elevation, alignment, and spacing of raceways. Install supports securely at ends and at intervals not to exceed **60 inches (1500 mm)**, to prevent movement during concrete pour.
  4. Level raceway components with finished slab and make adjustments for floor finishes.
  5. Adjust supports to maintain a **1/16- to 3/8-inch (1.6- to 10-mm)** finished concrete cover over preset inserts.
  6. Remove burrs, sharp edges, dents, and mechanical defects.
  7. Cap or plug boxes, insert- and service-fitting openings, and open ends of raceways.

8. Seal raceways, cells, junction boxes, and inserts to prevent water, concrete, or foreign matter from entering raceways before and during pouring slab or placing fill. Tape joints, or seal with compound, as recommended in writing by underfloor raceway manufacturer.
9. Junction Boxes: Install tops level and flush with finished floor. Install blank closure plates or plugs to close unused junction-box openings. Grout boxes in place to prevent movement during construction. Place top covers in inverted position during construction to prevent damage to surface of cover. Reinstall covers in proper position prior to final acceptance of Work.
10. Afterset Inserts: Cut, hole saw, and drill slab and raceways to allow for installation.
11. Ground underfloor raceway components.
12. Install a marker at the center of the last insert of each cell and channel of each straight run of metal underfloor service raceway to locate the insert and identify the system.
  - a. Install markers at last inserts on both sides of permanent walls and at first inserts adjacent to each junction box.
  - b. Install markers flush at screed line before pouring slab or placing fill. Extend marker with grommited screw when floor covering is placed. Do not extend through carpet.
  - c. Use slotted-head screw to identify electrical power; use Phillips-head screw to identify conventional communications.
  - d. Use another distinctive screw head to identify third system such as special-purpose wiring.
13. Level raceway components with finished slab and make adjustments in raceway component elevation to accommodate indicated floor finishes.

B. Field Quality Control

1. Perform tests and inspections.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
  - a. Perform visual inspection of interior of each junction box **OR** section of trench raceway, **as directed**, to verify absence of dirt, dust, construction debris, and moisture. Replace damaged and malfunctioning components.
  - b. Perform point-to-point tests of ground continuity and resistance of ground path between the most remote accessible fitting on each branch of each underfloor raceway system and the main electrical distribution grounding system.
    - 1) Determine cause and perform correction of any point-to-point resistance value that exceeds 0.05 ohms.
    - 2) Comply with NETA Acceptance Testing Specifications about safety, suitability of test equipment, test instrument calibration, and test report and records.

C. Cleaning

1. Clean and swab out underfloor raceways, inserts, and junction boxes after finish has been applied to floor slab, and remove foreign material, dirt, and moisture. Leave interiors clean and dry.

END OF SECTION 26 05 19 13



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Task	Specification	Specification Description
26 05 19 13	26 05 13 16a	Undercarpet Cables

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## SECTION 26 05 19 16 - COMMON WORK RESULTS FOR COMMUNICATIONS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for communications. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Communications equipment coordination and installation.
  - b. Sleeves for pathways and cables.
  - c. Sleeve seals.
  - d. Grout.
  - e. Common communications installation requirements.

#### C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

#### D. Submittals

1. Product Data: For sleeve seals.

### 1.2 PRODUCTS

#### A. Sleeves For Pathways And Cables

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
  - a. Minimum Metal Thickness:
    - 1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
    - 2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

#### B. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and pathway or cable.
  - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of pathway or cable.
  - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
  - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

#### C. Grout





1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

### 1.3 EXECUTION

#### A. Common Requirements For Communications Installation

1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

#### B. Sleeve Installation For Communications Penetrations

1. Communications penetrations occur when pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors **2 inches (50 mm)** above finished floor level.
7. Size pipe sleeves to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and pathway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
  - a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
11. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for **1-inch (25-mm)** annular clear space between pathway or cable and sleeve for installing mechanical sleeve seals.

#### C. Sleeve-Seal Installation

1. Install to seal exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for pathway or cable material and size. Position pathway or cable in center of sleeve. Assemble mechanical sleeve

seals and install in annular space between pathway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

D. Firestopping

1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping".

END OF SECTION 26 05 19 16

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## SECTION 26 05 19 16a - COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for common work results for electronic safety and security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Electronic safety and security equipment coordination and installation.
  - b. Sleeves for raceways and cables.
  - c. Sleeve seals.
  - d. Grout.
  - e. Common electronic safety and security installation requirements.

#### C. Definitions

1. EPDM: Ethylene-propylene-diene terpolymer rubber.
2. NBR: Acrylonitrile-butadiene rubber.

#### D. Submittals

1. Product Data: For sleeve seals.

### 1.2 PRODUCTS

#### A. Sleeves For Raceways And Cables

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel.
  - a. Minimum Metal Thickness:
    - 1) For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
    - 2) For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

#### B. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
  - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
  - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

#### C. Grout



1. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

### 1.3 EXECUTION

#### A. Common Requirements For Electronic Safety And Security Installation

1. Comply with NECA 1.
2. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
3. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
4. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
5. Right of Way: Give to piping systems installed at a required slope.

#### B. Sleeve Installation For Electronic Safety And Security Penetrations

1. Electronic safety and security penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
5. Cut sleeves to length for mounting flush with both surfaces of walls.
6. Extend sleeves installed in floors **2 inches (50 mm)** above finished floor level.
7. Size pipe sleeves to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and raceway or cable, unless indicated otherwise.
8. Seal space outside of sleeves with grout for penetrations of concrete and masonry
  - a. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
9. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".
10. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping".
11. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
12. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel **OR** cast-iron, **as directed**, pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
13. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for **1-inch (25-mm)** annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

#### C. Sleeve-Seal Installation

1. Install to seal exterior wall penetrations.

2. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- D. Firestopping
1. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping".

END OF SECTION 26 05 19 16a

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## SECTION 26 05 19 16b - ELECTRICAL RENOVATION

### 1.1 DESCRIPTION OF WORK

- A. This specification covers the furnishing and installation of materials for electrical renovation. Products shall be as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

### 1.2 GENERAL

- A. Quality Assurance
1. Regulatory Requirements: Comply with following:
    - a. Electrical: National Fire Protection Association (NFPA): NFPA 70 - National Electrical Code (NEC).
    - b. Accessibility:
      - 1) Architectural Barriers Act of 1968 as amended (42 USC 4151-4157) and HUD implementing regulations (24 CFR Part 40).
        - a) Uniform Federal Accessibility Standards (UFAS).
      - 2) Section 504 of the Rehabilitation Act of 1973 as amended (29 USC 794) and HUD implementing regulations 24 CFR Part 8.
      - 3) Fair Housing Accessibility Guidelines (24 CFR Chapter 1).
      - 4) Americans with Disabilities Act of 1990 (ADA) (42 USC §§ 12101, et seq.) and implementing regulations (28 CFR Part 35).
- B. Project Conditions
1. Existing Conditions: Buildings will be occupied during construction. See Division 1 Section "Summary of Work." Do not interfere with use of occupied portions of building. Maintain free and safe passage to and from occupied areas.
- C. Scheduling And Sequencing
1. Scheduling and Completion: Comply with requirements of Detailed Scope of Work.
- D. Alterations, Cutting And Protection
1. Protection: Protect existing finishes, equipment, utilities and adjacent work, which is scheduled to remain, from damage.
  2. Existing Operating Facilities: Confine operations to immediate vicinity of new work and do not interfere with or obstruct ingress or egress to and from adjacent facilities.

### 1.3 PRODUCTS

- A. Materials
1. Electrical Materials and Devices: Comply with NFPA 70 (NEC):
    - a. Boxes: Galvanized steel, not less than 1.6 mm (0.0625 inch) thickness (NEC 370-20) grounded in accordance with NEC, Article 250, suitable for recess mounting.
      - 1) Provide boxes of appropriate shape and size for intended purpose.
    - b. Devices:
      - 1) Duplex Receptacles: 15 A or 20 A 115 V, UL Listed with screw side connections and corrugated bearing pads.
        - a) GFI Outlets: 115 V, 60 Hz, 15/20 A rating, UL Listed.
      - 2) Switches: 15 A, 115 V, single pole, single throw switch, UL Listed, with side screw connections and corrugated bearing pads.



- a) Garbage Disposal: Heavy duty, 120/277 VAC, 60 Hz, single pole, single throw, 20 A rate, UL listed and CSA certified.
  - 3) Cover Plates: Smooth plastic in color to match existing.
- c. Wiring: Insulated wire, Type NM 600 V with ground wire, sized as appropriate for intended purpose and in accordance with NEC.
  - 1) Aluminum Wire: Not allowed unless existing wiring is aluminum.
  - 2) Provide necessary fittings in accordance with NEC.

#### 1.4 EXECUTION

##### A. Examination

1. Units, Spaces and Areas to be Renovated: Inspect to become familiar with existing conditions and to take measurements which are necessary for renovation work to be completed in accordance with contract requirements.
  - a. Carefully inspect condition of existing spaces including, but not limited to walls, floors, plumbing, electrical, etc. as essential to successful completion of renovation work.
  - b. Survey each space and verify dimensions for work.

##### B. Preparation

1. Building Occupation: Carry out renovation work to cause as little inconvenience to occupants as possible. See Division 1 Section "Summary of Work."
2. Protection: Protect and be responsible for existing buildings, facilities, utilities, and improvements within areas of construction operations.
  - a. Tenant's Property: Be responsible for any damage or loss to residents' property and to other work. Replace any material, which, in opinion of the Owner, has become damaged to extent that it could not be restored to its original condition.
  - b. Take precautions to protect residents and public from injury from construction operations.

##### C. Laying Out Work

1. Discrepancies: Verify dimensions and elevations indicated in layout of existing work.
  - a. Prior to commencing work, carefully compare and check Drawings (if any), for discrepancies in locations or elevations of work to be executed.
  - b. Refer discrepancies among Drawings (if any), Specifications and existing conditions to the Owner for adjustment before work affected is performed.
    - 1) Failure to make such notification shall place responsibility on Contractor to carry out work in satisfactory, workmanlike manner.
2. Contractor: Responsible for location and elevation of construction contemplated by Construction Documents.

##### D. Location Of Equipment And Piping

1. Drawings (if any) indicating location of equipment, piping, ductwork, etc. are diagrammatic and job conditions shall not always permit their installation in location shown. When this situation occurs, bring condition to the Owner's attention immediately. Relocation will be determined in joint conference.
2. Contractor: Do not relocate any items without first obtaining the Owner's acceptance. Remove and relocate such relocated items at own expense if so directed.

##### E. Electrical Work

1. General: Install boxes, wiring, and devices as indicated and required to connect and control electrical devices in accordance with NFPA 70 (NEC).
  - a. Boxes: Solidly anchor to framing or blocking.
2. Removing Electrical Switch or Duplex Outlet (Non-Hazardous Locations):
  - a. Box to Remain:
    - 1) Remove electrical device; cap hot and neutral with set-screw wire connectors.

- 2) Attach ground wire to remaining box with solid screw attachment.
      - 3) Provide and install natural finish aluminum blank cover plate with screw fasteners integral to match size of box remaining.
    - b. Box to be removed:
      - 1) Remove electrical device and box and pull wire out of wall back to first circuit panel, disconnecting from circuit panel.
      - 2) Patch and repair hole in partition to match existing.
  3. Garbage Disposal Electrical Hook-up: See Section "Plumbing." Comply with NFPA 70 (NEC):
    - a. Wiring: Install from disposal through concealed spaces to house panel, anchoring wire, and providing necessary fittings.
    - b. Switch: Install above counter top backsplash.
  4. Range Hood Electrical Hook-up: See Section "Residential Appliances." Comply with NFPA 70 (NEC):
    - a. Electric service: Install insulated wire from range hood through concealed spaces to house panel, anchoring wire, and providing necessary fittings.
  5. Water Heater Electrical Hook-up: See Division 15 Section "Domestic Water Heaters." Comply with NFPA 70 (NEC).
  6. Furnace Electrical Hook-up: See Section "Furnaces." Comply with NFPA 70 (NEC).
  7. Smoke Detector Electrical Hook-up: See "Fire Alarm." Comply with NFPA 70 (NEC).
- F. Integrating Existing Work
1. Protection: Protect existing improvements from damage.
    - a. Where new work is to be connected to existing work, exercise special care not to disturb or damage existing work more than necessary.
    - b. Damaged Work: Replace, repair and restored to its original condition at no cost to the Owner.

END OF SECTION 26 05 19 16b

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## SECTION 26 05 19 16c - CONTROL-VOLTAGE ELECTRICAL POWER CABLES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of control-voltage electrical power cables. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. UTP cabling.
  - b. 50/125 **OR** 62.5/125, **as directed**, -micrometer, multimode optical fiber cabling.
  - c. RS-232 cabling.
  - d. RS-485 cabling.
  - e. Low-voltage control cabling.
  - f. Control-circuit conductors.
  - g. Identification products.

#### C. Definitions

1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel section.
3. EMI: Electromagnetic interference.
4. IDC: Insulation displacement connector.
5. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
6. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
7. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
8. RCDD: Registered Communications Distribution Designer.
9. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal side rails, and a bottom without ventilation openings.
10. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.
11. UTP: Unshielded twisted pair.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Field quality-control reports.
3. Maintenance data.

#### E. Quality Assurance

1. Testing Agency Qualifications: Member company of an NRTL.
  - a. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing **OR** possess the standards and experience for membership, **as directed**.
2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  - a. Flame-Spread Index: 25 or less.
  - b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.



3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

F. Delivery, Storage, And Handling

1. Test cables upon receipt at Project site.
  - a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight **OR** optical loss test set, **as directed**.
  - b. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
  - c. Test each pair of UTP cable for open and short circuits.

## 1.2 PRODUCTS

A. Pathways

1. Support of Open Cabling: NRTL labeled for support of Category 5e **OR** Category 6, **as directed**, cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
  - a. Support brackets with cable tie slots for fastening cable ties to brackets.
  - b. Lacing bars, spools, J-hooks, and D-rings.
  - c. Straps and other devices.
2. Cable Trays:
  - a. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than **0.000472 inch (0.012 mm)** thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than **0.002165 inch (0.055 mm)** thick, **as directed**.
    - 1) Basket Cable Trays: **6 inches (150 mm)** wide and **2 inches (50 mm)** deep. Wire mesh spacing shall not exceed **2 by 4 inches (50 by 100 mm)**.
    - 2) Trough or Ventilated Cable Trays: Nominally **6 inches (150 mm)** wide.
    - 3) Ladder Cable Trays: Nominally **18 inches (455 mm)** wide, and a rung spacing of **12 inches (305 mm)**.
    - 4) Channel Cable Trays: One-piece construction, nominally **4 inches (100 mm)** wide. Slot spacing shall not exceed **4-1/2 inches (115 mm)** o.c.
    - 5) Solid-Bottom or Nonventilated Cable Trays: One-piece construction, nominally **12 inches (305 mm)** wide. Provide with **OR** without, **as directed**, solid covers.
3. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used, **as directed**.
  - a. Outlet boxes shall be no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.

B. Backboards

1. Description: Plywood, fire-retardant treated, **as directed**, **3/4 by 48 by 96 inches (19 by 1220 by 2440 mm)**. Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry".

C. UTP Cable

1. Description: 100-ohm, four-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket, **as directed**.
  - a. Comply with ICEA S-90-661 for mechanical properties.
  - b. Comply with TIA/EIA-568-B.1 for performance specifications.
  - c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **as directed**.
  - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

- 1) Communications, General Purpose: Type CM or Type CMG; or Type MPP, Type CMP, Type MPR, Type CMR, Type MP, or Type MPG, **as directed**.
- 2) Communications, Plenum Rated: Type CMP or Type MPP, **as directed**, complying with NFPA 262.
- 3) Communications, Riser Rated: Type CMR; or Type MPP, Type CMP, or Type MPR, **as directed**; complying with UL 1666.
- 4) Communications, Limited Purpose: Type CMX; or Type MPP, Type CMP, Type MPR, Type CMR, Type MP, Type MPG, Type CM, or Type CMG, **as directed**.
- 5) Multipurpose: Type MP or Type MPG; or Type MPP or Type MPR, **as directed**.
- 6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
- 7) Multipurpose, Riser Rated: Type MPR or Type MPP, **as directed**, complying with UL 1666.

D. UTP Cable Hardware

1. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
2. Connecting Blocks: 110 style for Category 5e **OR** 110 style for Category 6 **OR** 66 style for Category 5e, **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare; integral with connector bodies, including plugs and jacks where indicated.

E. Optical Fiber Cable

1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
  - a. Comply with ICEA S-83-596 for mechanical properties.
  - b. Comply with TIA/EIA-568-B.3 for performance specifications.
  - c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
  - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
    - 1) General Purpose, Nonconductive: Type OFN or OFNG, or Type OFNR or Type OFNP, **as directed**.
    - 2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    - 3) Riser Rated, Nonconductive: Type OFNR or Type OFNP, **as directed**, complying with UL 1666.
    - 4) General Purpose, Conductive: Type OFC or Type OFCG; or Type OFNG, Type OFN, Type OFCR, Type OFNR, Type OFCP, or Type OFNP, **as directed**.
    - 5) Plenum Rated, Conductive: Type OFCP or Type OFNP, **as directed**, complying with NFPA 262.
    - 6) Riser Rated, Conductive: Type OFCR; or Type OFNR, Type OFCP, or Type OFNP, **as directed**; complying with UL 1666.
  - e. Conductive cable shall be steel **OR** aluminum, **as directed**,-armored type.
  - f. Maximum Attenuation: 3.5 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
  - g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
2. Jacket:
  - a. Jacket Color: Aqua for 50/125 **OR** Orange for 62.5/125, **as directed**,-micrometer cable.
  - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
  - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Optical Fiber Cable Hardware

1. Cable Connecting Hardware: Comply with the Fiber Optic Connector Interchangeability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
  - a. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
  - b. Type SFF connectors may be used in termination racks, panels, and equipment packages.



**G. RS-232 Cable**

1. **Standard Cable: NFPA 70, Type CM.**
  - a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
  - b. Polypropylene insulation.
  - c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
  - d. PVC jacket.
  - e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
  - f. Flame Resistance: Comply with UL 1581.
2. **Plenum-Rated Cable: NFPA 70, Type CMP.**
  - a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
  - b. Plastic insulation.
  - c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
  - d. Plastic jacket.
  - e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned-copper drain wire.
  - f. Flame Resistance: Comply with NFPA 262.

**H. RS-485 Cable**

1. **Standard Cable: NFPA 70, Type CM or Type CMG, as directed.**
  - a. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
  - b. PVC insulation.
  - c. Unshielded.
  - d. PVC jacket.
  - e. Flame Resistance: Comply with UL 1581.
2. **Plenum-Rated Cable: NFPA 70, Type CMP.**
  - a. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned-copper conductors.
  - b. Fluorinated ethylene propylene insulation.
  - c. Unshielded.
  - d. Fluorinated ethylene propylene jacket.
  - e. Flame Resistance: NFPA 262, Flame Test.

**I. Low-Voltage Control Cable**

1. **Paired Cable: NFPA 70, Type CMG.**
  - a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
  - b. PVC insulation.
  - c. Unshielded.
  - d. PVC jacket.
  - e. Flame Resistance: Comply with UL 1581.
2. **Plenum-Rated, Paired Cable: NFPA 70, Type CMP.**
  - a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
  - b. PVC insulation.
  - c. Unshielded.
  - d. PVC jacket.
  - e. Flame Resistance: Comply with NFPA 262.
3. **Paired Cable: NFPA 70, Type CMG.**
  - a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
  - b. PVC insulation.
  - c. Unshielded.
  - d. PVC jacket.
  - e. Flame Resistance: Comply with UL 1581.
4. **Plenum-Rated, Paired Cable: NFPA 70, Type CMP.**
  - a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned-copper conductors.
  - b. Fluorinated ethylene propylene insulation.
  - c. Unshielded.

- d. Plastic jacket.
  - e. Flame Resistance: NFPA 262, Flame Test.
- J. Control-Circuit Conductors
- 1. Class 1 Control Circuits: Stranded copper, Type THHN-THWN **OR** Type XHHN, **as directed**, in raceway, complying with UL 83 **OR** UL 44, **as directed**.
  - 2. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway **OR** Type XHHN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**, complying with UL 83 **OR** UL 44, **as directed**.
  - 3. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF, complying with UL 83.
- K. Identification Products
- 1. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
  - 2. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
- L. Source Quality Control
- 1. Testing Agency: Engage a qualified testing agency to evaluate cables.
  - 2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
  - 3. Factory test UTP cables according to TIA/EIA-568-B.2.
  - 4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
  - 5. Cable will be considered defective if it does not pass tests and inspections.
  - 6. Prepare test and inspection reports.

### 1.3 EXECUTION

- A. Installation Of Pathways
- 1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
  - 2. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
  - 3. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
  - 4. Install manufactured conduit sweeps and long-radius elbows if possible.
  - 5. Pathway Installation in Equipment Rooms:
    - a. Position conduit ends adjacent to a corner on backboard if a single piece of plywood is installed or in the corner of room if multiple sheets of plywood are installed around perimeter walls of room.
    - b. Install cable trays to route cables if conduits cannot be located in these positions.
    - c. Secure conduits to backboard if entering room from overhead.
    - d. Extend conduits **3 inches (75 mm)** above finished floor.
    - e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
  - 6. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly and form smooth gap-free corners and joints.
- B. Installation Of Conductors And Cables
- 1. Comply with NECA 1.
  - 2. General Requirements for Cabling:
    - a. Comply with TIA/EIA-568-B.1.
    - b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
    - c. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.

- d. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- e. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
- f. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- g. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
- h. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
3. UTP Cable Installation:
  - a. Comply with TIA/EIA-568-B.2.
  - b. Install 110-style IDC termination hardware unless otherwise indicated.
  - c. Do not untwist UTP cables more than **1/2 inch (12 mm)** from the point of termination to maintain cable geometry.
4. Installation of Control-Circuit Conductors:
  - a. Install wiring in raceways. Comply with requirements specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
5. Optical Fiber Cable Installation:
  - a. Comply with TIA/EIA-568-B.3.
  - b. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
6. Open-Cable Installation:
  - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
  - b. Suspend copper cable not in a wireway or pathway a minimum of **8 inches (200 mm)** above ceilings by cable supports not more than **60 inches (1525 mm)** apart.
  - c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
7. Installation of Cable Routed Exposed under Raised Floors:
  - a. Install plenum-rated cable only.
  - b. Install cabling after the flooring system has been installed in raised floor areas.
  - c. Coil cable **72 inches (1830 mm)** long shall be neatly coiled not less than **12 inches (305 mm)** in diameter below each feed point.
8. Separation from EMI Sources:
  - a. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
  - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of **5 inches (127 mm)**.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **12 inches (305 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **24 inches (600 mm)**.
  - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of **2-1/2 inches (64 mm)**.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **6 inches (150 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **12 inches (305 mm)**.
  - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

- 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
  - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **3 inches (75 mm)**.
  - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **6 inches (150 mm)**.
  - e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of **48 inches (1200 mm)**.
  - f. Separation between Cables and Fluorescent Fixtures: A minimum of **5 inches (127 mm)**.
- C. Removal Of Conductors And Cables
1. Remove abandoned conductors and cables.
- D. Control-Circuit Conductors
1. Minimum Conductor Sizes:
    - a. Class 1 remote-control and signal circuits, No 14 AWG.
    - b. Class 2 low-energy, remote-control, and signal circuits, No. 16 AWG.
    - c. Class 3 low-energy, remote-control, alarm, and signal circuits, No 12 AWG.
- E. Firestopping
1. Comply with requirements in Division 07 Section "Penetration Firestopping".
  2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
  3. Comply with BICSI TDMM, "Firestopping Systems" Article.
- F. Grounding
1. For data communication wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
  2. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".
- G. Identification
- H. Identify system components, wiring, and cabling according to TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
- I. Field Quality Control
1. Perform tests and inspections.
  2. Tests and Inspections:
    - a. Visually inspect UTP and optical fiber cable jacket materials for UL or third-party certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
    - b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
    - c. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross connection.
      - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    - d. Optical Fiber Cable Tests:
      - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      - 2) Link End-to-End Attenuation Tests:
        - a) Multimode Link Measurements: Test at 850 or 1300 nm in one direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.



- b) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
3. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 26 05 19 16c

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## SECTION 26 05 19 16d - COMMUNICATIONS EQUIPMENT ROOM FITTINGS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for communications equipment room fittings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Telecommunications mounting elements.
  - b. Backboards.
  - c. Telecommunications equipment racks and cabinets.
  - d. Telecommunications service entrance pathways.
  - e. Grounding.

#### C. Definitions

1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. BICSI: Building Industry Consulting Service International.
3. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel not exceeding 6 inches (152 mm) in width.
4. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
5. LAN: Local area network.
6. RCDD: Registered Communications Distribution Designer.
7. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of a bottom without ventilation openings within integral or separate longitudinal side rails.
8. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.

#### D. Performance Requirements

1. Seismic Performance: Floor-mounted cabinets and cable pathways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
  - c. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.
3. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
4. Seismic Qualification Certificates: For floor-mounted cabinets, accessories, and components, from manufacturer.



- a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Base certification on the maximum number of components capable of being mounted in each rack type. Identify components on which certification is based.
- c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Quality Assurance

1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff **OR** personnel must possess the standards and experience for membership.
  - a. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD **OR** RCDD/NTS **OR** possess the standards and experience for membership **OR** Commercial Installer, Level 2, **as directed**.
  - b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.
  - c. Field Inspector: Currently registered by BICSI as RCDD **OR** possess the standards and experience for membership **OR** Commercial Installer, Level 2, **as directed**, to perform the on-site inspection.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
4. Grounding: Comply with ANSI-J-STD-607-A.

G. Project Conditions

1. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

H. Coordination

1. Coordinate layout and installation of communications equipment with the Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.
  - a. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and the Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
  - b. Record agreements reached in meetings and distribute them to other participants.
  - c. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
  - d. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
2. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

1.2 PRODUCTS

A. Pathways

1. General Requirements: Comply with TIA/EIA-569-A.



2. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.
    - a. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
    - b. Support brackets with cable tie slots for fastening cable ties to brackets.
    - c. Lacing bars, spools, J-hooks, and D-rings.
    - d. Straps and other devices.
  3. Cable Trays:
    - a. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than **0.00472 inch (0.12 mm)** thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than **0.002165 inch (0.055 mm)** thick, **as directed**.
      - 1) Basket Cable Trays: **6 inches (150 mm)** wide and **2 inches (50 mm)** deep. Wire mesh spacing shall not exceed **2 by 4 inches (50 by 100 mm)**.
      - 2) Trough Cable Trays: Nominally **6 inches (150 mm)** wide.
      - 3) Ladder Cable Trays: Nominally **18 inches (455 mm)** wide, and a rung spacing of **12 inches (305 mm)**.
      - 4) Channel Cable Trays: One-piece construction, nominally **4 inches (100 mm)** wide. Slot spacing shall not exceed **4-1/2 inches (115 mm)** o.c.
      - 5) Solid-Bottom Cable Trays: One-piece construction, nominally **12 inches (305 mm)** wide. Provide with **OR** without, **as directed**, solid covers.
  4. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used.
    - a. Outlet boxes shall be no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
- B. Backboards
1. Backboards: Plywood, fire-retardant treated, **as directed**, **3/4 by 48 by 96 inches (19 by 1220 by 2440 mm)**. Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry".
- C. Equipment Frames
1. General Frame Requirements:
    - a. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
    - b. Module Dimension: Width compatible with EIA 310 standard, **19-inch (480-mm)** panel mounting.
    - c. Finish: Manufacturer's standard, baked-polyester powder coat.
  2. Floor-Mounted Racks: Modular-type, steel **OR** aluminum, **as directed**, construction.
    - a. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip, **as directed**.
    - b. Baked-polyester powder coat finish.
  3. Modular Freestanding Cabinets:
    - a. Removable and lockable side panels.
    - b. Hinged and lockable front and rear doors.
    - c. Adjustable feet for leveling.
    - d. Screened ventilation openings in the roof and rear door.
    - e. Cable access provisions in the roof and base.
    - f. Grounding bus bar.
    - g. Rack **OR** Roof, **as directed**, -mounted, **550-cfm (260-L/s)** fan with filter.
    - h. Power strip.
    - i. Baked-polyester powder coat finish.
    - j. All cabinets keyed alike.

4. Modular Wall Cabinets:
  - a. Wall mounting.
  - b. Steel **OR** Aluminum, **as directed**, construction.
  - c. Treated to resist corrosion.
  - d. Lockable front and rear doors.
  - e. Louvered side panels.
  - f. Cable access provisions top and bottom.
  - g. Grounding lug.
  - h. Rack **OR** Roof, **as directed**, -mounted, 250-cfm (118-L/s) fan.
  - i. Power strip.
  - j. All cabinets keyed alike.
5. Cable Management for Equipment Frames:
  - a. Metal, with integral wire retaining fingers.
  - b. Baked-polyester powder coat finish.
  - c. Vertical cable management panels shall have front and rear channels, with covers.
  - d. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

#### D. Power Strips

1. Power Strips: Comply with UL 1363.
  - a. Rack mounting.
  - b. Six, 15-A, 120-V ac, NEMA WD 6, Configuration 5-15R **OR** 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R, **as directed**, receptacles.
  - c. LED indicator lights for power and protection status.
  - d. LED indicator lights for reverse polarity and open outlet ground.
  - e. Circuit Breaker and Thermal Fusing:
    - 1) When protection is lost, circuit opens and cannot be reset.

**OR**

Unit continues to supply power if protection is lost.
  - f. Close-coupled, direct plug-in **OR** Cord connected with 15-foot (4.5-m), **as directed**, line cord.
  - g. Rocker-type on-off switch, illuminated when in on position.
  - h. Peak Single-Impulse Surge Current Rating: 33 **OR** 26 **OR** 13, **as directed**, kA per phase.
  - i. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.

#### E. Grounding

1. Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems" for grounding conductors and connectors.
2. Telecommunications Main Bus Bar:
  - a. Connectors: Mechanical type, cast silicon bronze, solderless compression **OR** exothermic, **as directed**, -type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
  - b. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
  - c. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
3. Comply with ANSI-J-STD-607-A.

#### F. Labeling

1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

### 1.3 EXECUTION

- A. Entrance Facilities
  - 1. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.
  - 2. Install underground **OR** buried **OR** aerial, **as directed**, pathways complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Article.
    - a. Install underground **OR** buried, **as directed**, entrance pathway complying with Division 26 Section "Raceway And Boxes For Electrical Systems".
- B. Installation
  - 1. Comply with NECA 1.
  - 2. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
  - 3. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
  - 4. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
- C. Firestopping
  - 1. Comply with requirements in Division 07 Section "Penetration Firestopping".
  - 2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
  - 3. Comply with BICSI TDMM, "Firestopping Systems" Article.
- D. Grounding
  - 1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
  - 2. Comply with ANSI-J-STD-607-A.
  - 3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least **2-inch (50-mm)** clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
  - 4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
    - a. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.
- E. Identification
  - 1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
  - 2. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
  - 3. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 **OR** Class 3 **OR** Class 4, **as directed**, level of administration including optional identification requirements of this standard, **as directed**.
  - 4. Labels shall be preprinted or computer-printed type.

END OF SECTION 26 05 19 16d

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## SECTION 26 05 19 16e - COMMUNICATIONS BACKBONE CABLING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for communications backbone cabling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Pathways.
  - b. UTP cable.
  - c. 50/125 and 62.5/125-micrometer, optical fiber cabling.
  - d. Coaxial cable.
  - e. Cable connecting hardware, patch panels, and cross-connects.
  - f. Cabling identification products.

#### C. Definitions

1. BICSI: Building Industry Consulting Service International.
2. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
3. EMI: Electromagnetic interference.
4. IDC: Insulation displacement connector.
5. LAN: Local area network.
6. RCDD: Registered Communications Distribution Designer.
7. UTP: Unshielded twisted pair.

#### D. Backbone Cabling Description

1. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
2. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

#### E. Performance Requirements

1. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

#### F. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings:
  - a. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by the Owner.
  - b. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
  - c. Cabling administration drawings and printouts.
  - d. Wiring diagrams to show typical wiring schematics including the following:
    - 1) Cross-connects.
    - 2) Patch panels.
    - 3) Patch cords.

- e. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
    - f. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements.
  - 3. Qualification Data: For Installer, **as directed**, qualified layout technician, installation supervisor, and field inspector.
  - 4. Source quality-control reports.
  - 5. Field quality-control reports.
  - 6. Maintenance Data.
  - 7. Software and Firmware Operational Documentation:
    - a. Software operating and upgrade manuals.
    - b. Program Software Backup: On magnetic media or compact disk, complete with data files.
    - c. Device address list.
    - d. Printout of software application and graphic screens.
- G. Quality Assurance
  - 1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff **OR** personnel must possess the standards and experience for membership, **as directed**.
    - a. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD **OR** personnel that possess the standards and experience for membership, **as directed**.
    - b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.
  - 2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
    - a. Flame-Spread Index: 25 or less.
    - b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
  - 3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 4. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
  - 5. Grounding: Comply with ANSI-J-STD-607-A.
- H. Delivery, Storage, And Handling
  - 1. Test cables upon receipt at Project site.
    - a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
    - b. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
    - c. Test each pair of UTP cable for open and short circuits.
- I. Software Service Agreement
  - 1. Technical Support: Beginning with Final Completion, provide software support for two years.
  - 2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
    - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

## 1.2 PRODUCTS

### A. Pathways

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
  - a. Support brackets with cable tie slots for fastening cable ties to brackets.
  - b. Lacing bars, spools, J-hooks, and D-rings.
  - c. Straps and other devices.
3. Cable Trays:
  - a. Cable Tray Material: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than **0.000472 inches (0.012 mm)** thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than **0.002165 inches (0.055 mm)** thick, **as directed**.
    - 1) Basket Cable Trays: **6 inches (150 mm)** wide and **2 inches (50 mm)** deep. Wire mesh spacing shall not exceed **2 by 4 inches (50 by 100 mm)**.
    - 2) Trough Cable Trays: Nominally **6 inches (150 mm)** wide.
    - 3) Ladder Cable Trays: Nominally **18 inches (455 mm)** wide, and a rung spacing of **12 inches (305 mm)**.
    - 4) Channel Cable Trays: One-piece construction, nominally **4 inches (100 mm)** wide. Slot spacing shall not exceed **4-1/2 inches (115 mm)** o.c.
    - 5) Solid-Bottom Cable Trays: One-piece construction, nominally **12 inches (305 mm)** wide. Provide with **OR** without, **as directed**, solid covers.
4. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used.
  - a. Outlet boxes shall be no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.

### B. Backboards

1. Backboards: Plywood, fire-retardant treated, **as directed**, **3/4 by 48 by 96 inches (19 by 1220 by 2440 mm)**. Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.

### C. UTP Cable

1. Description: 100-ohm, 100-pair UTP, formed into 25-pair binder groups covered with a gray thermoplastic jacket and overall metallic shield.
  - a. Comply with ICEA S-90-661 for mechanical properties.
  - b. Comply with TIA/EIA-568-B.1 for performance specifications.
  - c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
  - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
    - 1) Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
    - 2) Communications, Plenum Rated: Type CMP or MPP, **as directed**, complying with NFPA 262.
    - 3) Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, **as directed**, complying with UL 1666.
    - 4) Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
    - 5) Multipurpose: Type MP or MPG; or MPP or MPR, **as directed**.
    - 6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
    - 7) Multipurpose, Riser Rated: Type MPR or MPP, **as directed**, complying with UL 1666.

### D. UTP Cable Hardware





1. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
2. Connecting Blocks: 110-style IDC for Category 5e **OR** 110-style IDC for Category 6 **OR** 66-style IDC for Category 5e, **OR** 110-style IDC for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
3. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
  - a. Number of Terminals per Field: One for each conductor in assigned cables.
4. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
  - a. Number of Jacks per Field: One for each four-pair UTP cable indicated **OR** conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria, **as directed**.
5. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
6. Patch Cords: Factory-made, 4-pair cables in **36-inch (900-mm)** **OR** **48-inch (1200-mm)**, **as directed**, lengths; terminated with 8-position modular plug at each end.
  - a. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
  - b. Patch cords shall have color-coded boots for circuit identification.

#### E. Optical Fiber Cable

1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**, -micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
  - a. Comply with ICEA S-83-596 for mechanical properties.
  - b. Comply with TIA/EIA-568-B.3 for performance specifications.
  - c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
  - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
    - 1) General Purpose, Nonconductive: Type OFN or OFNG, or OFNR, OFNP, **as directed**.
    - 2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    - 3) Riser Rated, Nonconductive: Type OFNR or OFNP, **as directed**, complying with UL 1666.
    - 4) General Purpose, Conductive: Type OFC or OFCG; or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
    - 5) Plenum Rated, Conductive: Type OFCP or OFNP, **as directed**, complying with NFPA 262.
    - 6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **as directed**, complying with UL 1666.
  - e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
  - f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
  - g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
2. Jacket:
  - a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
  - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
  - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm)**.

#### F. Optical Fiber Cable Hardware

1. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
    - a. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
  2. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.
  3. Cable Connecting Hardware:
    - a. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
    - b. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
    - c. Type SFF connectors may be used in termination racks, panels, and equipment packages.
- G. Coaxial Cable
1. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
  2. RG-11/U: NFPA 70, Type CATV.
    - a. No. 14 AWG, solid, copper-covered steel conductor.
    - b. Gas-injected, foam-PE insulation.
    - c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
    - d. Jacketed with sunlight-resistant, black PVC or PE.
    - e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
  3. RG59/U: NFPA 70, Type CATVR.
    - a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
    - b. Gas-injected, foam-PE insulation.
    - c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
    - d. Color-coded PVC jacket.
  4. RG-6/U: NFPA 70, Type CATV or CM.
    - a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
    - b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
    - c. Jacketed with black PVC or PE.
    - d. Suitable for indoor installations.
  5. RG59/U: NFPA 70, Type CATV.
    - a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
    - b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
    - c. PVC jacket.
  6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
    - a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
    - b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
    - c. Copolymer jacket.
  7. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
    - a. CATV Cable: Type CATV, or CATVP or CATVR, **as directed**.
    - b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
    - c. CATV Riser Rated: Type CATVR; or CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
    - d. CATV Limited Rating: Type CATVX.
- H. Coaxial Cable Hardware
1. Coaxial-Cable Connectors: Type BNC, 75 ohms.
- I. Grounding

1. Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems" for grounding conductors and connectors.
2. Comply with ANSI-J-STD-607-A.

J. Identification Products

1. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

K. Source Quality Control

1. Testing Agency: Engage a qualified testing agency to evaluate cables.
2. Factory test cables on reels according to TIA/EIA-568-B.1.
3. Factory test UTP cables according to TIA/EIA-568-B.2.
4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
5. Cable will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports.

### 1.3 EXECUTION

A. Entrance Facilities

1. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

B. Wiring Methods

1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
  - a. Install plenum cable in environmental air spaces, including plenum ceilings.
  - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

C. Installation Of Pathways

1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.
2. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings". Drawings indicate general arrangement of pathways and fittings.
3. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
4. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
5. Install manufactured conduit sweeps and long-radius elbows whenever possible.
6. Pathway Installation in Communications Equipment Rooms:
  - a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
  - b. Install cable trays to route cables if conduits cannot be located in these positions.
  - c. Secure conduits to backboard when entering room from overhead.
  - d. Extend conduits **3 inches (76 mm)** above finished floor.

- e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
7. Backboards: Install backboards with **96-inch (2440-mm)** dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

D. Installation Of Cables

1. Comply with NECA 1.
2. General Requirements for Cabling:
  - a. Comply with TIA/EIA-568-B.1.
  - b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
  - c. Install 110-style IDC termination hardware unless otherwise indicated.
  - d. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
  - e. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
  - f. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
  - g. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
  - h. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
  - i. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
  - j. In the communications equipment room, install a **10-foot- (3-m-)** long service loop on each end of cable.
  - k. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
3. UTP Cable Installation:
  - a. Comply with TIA/EIA-568-B.2.
  - b. Do not untwist UTP cables more than **1/2 inch (12 mm)** from the point of termination to maintain cable geometry.
4. Optical Fiber Cable Installation:
  - a. Comply with TIA/EIA-568-B.3.
  - b. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
5. Open-Cable Installation:
  - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
  - b. Suspend UTP cable not in a wireway or pathway, a minimum of **8 inches (200 mm)** above ceilings by cable supports not more than **60 inches (1524 mm)** apart.
  - c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
6. Installation of Cable Routed Exposed under Raised Floors:
  - a. Install plenum-rated cable only.
  - b. Install cabling after the flooring system has been installed in raised floor areas.
  - c. Coil cable **6 feet (1800 mm)** long not less than **12 inches (300 mm)** in diameter below each feed point.
7. Outdoor Coaxial Cable Installation:
  - a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
  - b. Attach antenna lead-in cable to support structure at intervals not exceeding **36 inches (915 mm)**.
8. Group connecting hardware for cables into separate logical fields.
9. Separation from EMI Sources:



- a. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
  - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of **5 inches (127 mm)**.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **12 inches (300 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **24 inches (610 mm)**.
  - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of **2-1/2 inches (64 mm)**.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **6 inches (150 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **12 inches (300 mm)**.
  - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **3 inches (76 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **6 inches (150 mm)**.
  - e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of **48 inches (1200 mm)**.
  - f. Separation between Communications Cables and Fluorescent Fixtures: A minimum of **5 inches (127 mm)**.
- E. Firestopping
1. Comply with requirements in Division 07 Section "Penetration Firestopping".
  2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
  3. Comply with BICSI TDMM, "Firestopping Systems" Article.
- F. Grounding
1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
  2. Comply with ANSI-J-STD-607-A.
  3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least **2-inch (50-mm)** clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
  4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
- G. Identification
1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
    - a. Administration Class: **1 OR 2 OR 3 OR 4, as directed**.
    - b. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.
  2. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
  3. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class **2 OR Class 3 OR Class 4, as directed**, level of administration including optional identification requirements of this standard.



4. Comply with requirements in Division 27 Section "Communications Horizontal Cabling" for cable and asset management software.
  5. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
  6. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
  7. Cable and Wire Identification:
    - a. Label each cable within **4 inches (100 mm)** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
    - b. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
    - c. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 feet (4.5 m)**.
    - d. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
      - 1) Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
      - 2) Label each unit and field within distribution racks and frames.
    - e. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
  8. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:
    - a. Cables use flexible vinyl or polyester that flexes as cables are bent.
- H. Field Quality Control
1. Tests and Inspections:
    - a. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
    - b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
    - c. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
      - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    - d. Optical Fiber Cable Tests:
      - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
      - 2) Link End-to-End Attenuation Tests:



- a) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
  - b) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
2. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
3. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 26 05 19 16e

NOT FOR BID



## SECTION 26 05 19 16f - COMMUNICATIONS HORIZONTAL CABLING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for communications horizontal cabling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Pathways.
  - b. UTP cabling.
  - c. 50/125 and 62.5/125-micrometer, optical fiber cabling.
  - d. Coaxial cable.
  - e. Multiuser telecommunications outlet assemblies.
  - f. Cable connecting hardware, patch panels, and cross-connects.
  - g. Telecommunications outlet/connectors.
  - h. Cabling system identification products.
  - i. Cable management system.

#### C. Definitions

1. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.
2. BICSI: Building Industry Consulting Service International.
3. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel.
4. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
5. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
6. EMI: Electromagnetic interference.
7. IDC: Insulation displacement connector.
8. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).
9. LAN: Local area network.
10. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.
11. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
12. RCDD: Registered Communications Distribution Designer.
13. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom without ventilation openings.
14. Trough or Ventilated Cable Tray: A fabricated structure consisting of longitudinal side rails and a bottom having openings for the passage of air.
15. UTP: Unshielded twisted pair.

#### D. Horizontal Cabling Description

1. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.
  - a. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.

- b. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
- c. Bridged taps and splices shall not be installed in the horizontal cabling.
- d. Splitters shall not be installed as part of the optical fiber cabling.
- 2. A work area is approximately **100 sq. ft. (9.3 sq. m)**, and includes the components that extend from the telecommunications outlet/connectors to the station equipment.
- 3. The maximum allowable horizontal cable length is **295 feet (90 m)**. This maximum allowable length does not include an allowance for the length of **16 feet (4.9 m)** to the workstation equipment. The maximum allowable length does not include an allowance for the length of **16 feet (4.9 m)** in the horizontal cross-connect.

E. Performance Requirements

- 1. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

F. Submittals

- 1. Product Data: For each type of product indicated.
- 2. Shop Drawings:
  - a. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by the Owner.
  - b. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
  - c. Cabling administration drawings and printouts.
  - d. Wiring diagrams to show typical wiring schematics, including the following:
    - 1) Cross-connects.
    - 2) Patch panels.
    - 3) Patch cords.
  - e. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
  - f. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements.
- 3. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration and faceplates for color selection and evaluation of technical features.
- 4. Qualification Data: For Installer, **as directed**, qualified layout technician, installation supervisor, and field inspector.
- 5. Source quality-control reports.
- 6. Field quality-control reports.
- 7. Maintenance Data.
- 8. Software and Firmware Operational Documentation:
  - a. Software operating and upgrade manuals.
  - b. Program Software Backup: On magnetic media or compact disk, complete with data files.
  - c. Device address list.
  - d. Printout of software application and graphic screens.

G. Quality Assurance

- 1. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff **OR** personnel must possess the standards and experience for membership, **as directed**.
  - a. Layout Responsibility: Preparation of Shop Drawings, Cabling Administration Drawings, and field testing program development by an RCDD **OR** personnel that possess the standards and experience for membership, **as directed**.
  - b. Installation Supervision: Installation shall be under the direct supervision of Registered Technician **OR** Level 2 Installer, **as directed**, who shall be present at all times when Work of this Section is performed at Project site.

2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  - a. Flame-Spread Index: 25 or less.
  - b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
5. Grounding: Comply with ANSI-J-STD-607-A.

H. Delivery, Storage, And Handling

1. Test cables upon receipt at Project site.
  - a. Test optical fiber cables to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
  - b. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
  - c. Test each pair of UTP cable for open and short circuits.

I. Software Service Agreement

1. Technical Support: Beginning with Final Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
  - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Pathways

1. General Requirements: Comply with TIA/EIA-569-A.
2. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
  - a. Support brackets with cable tie slots for fastening cable ties to brackets.
  - b. Lacing bars, spools, J-hooks, and D-rings.
  - c. Straps and other devices.
3. Cable Trays:
  - a. Cable Tray Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than **0.000472 inch (0.012 mm)** thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M, Grade 0.55, not less than **0.002165 inch (0.055 mm)** thick, **as directed**.
    - 1) Basket Cable Trays: **6 inches (150 mm)** wide and **2 inches (50 mm)** deep. Wire mesh spacing shall not exceed **2 by 4 inches (50 by 100 mm)**.
    - 2) Trough Cable Trays: Nominally **6 inches (150 mm)** wide.
    - 3) Ladder Cable Trays: Nominally **18 inches (455 mm)** wide, and a rung spacing of **12 inches (305 mm)**.
    - 4) Channel Cable Trays: One-piece construction, nominally **4 inches (100 mm)** wide. Slot spacing shall not exceed **4-1/2 inches (115 mm)** o.c.
    - 5) Solid-Bottom Cable Trays: One-piece construction, nominally **12 inches (305 mm)** wide. Provide with **OR** without, **as directed**, solid covers.
4. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used.



- a. Outlet boxes shall be no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
  - B. Backboards
    1. Backboards: Plywood, fire-retardant treated, **as directed**, **3/4 by 48 by 96 inches (19 by 1220 by 2440 mm)**. Comply with requirements in Division 06 Section "Rough Carpentry" for plywood backing panels.
  - C. UTP Cable
    1. Description: 100-ohm, 4-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.
      - a. Comply with ICEA S-90-661 for mechanical properties.
      - b. Comply with TIA/EIA-568-B.1 for performance specifications.
      - c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
      - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
        - 1) Communications, General Purpose: Type CM or CMG; or MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
        - 2) Communications, Plenum Rated: Type CMP or MPP, **as directed**, complying with NFPA 262.
        - 3) Communications, Riser Rated: Type CMR; or MPP, CMP, or MPR, **as directed**, complying with UL 1666.
        - 4) Communications, Limited Purpose: Type CMX; or MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
        - 5) Multipurpose: Type MP or MPG; or MPP or MPR, **as directed**.
        - 6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
        - 7) Multipurpose, Riser Rated: Type MPR or MPP, **as directed**, complying with UL 1666.
  - D. UTP Cable Hardware
    1. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
    2. Connecting Blocks: 110-style IDC for Category 5e **OR** 110-style IDC for Category 6 **OR** 66-style IDC for Category 5e, **OR** 110-style IDC for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.
    3. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
      - a. Number of Terminals per Field: One for each conductor in assigned cables.
    4. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.
      - a. Number of Jacks per Field: One for each four-pair UTP cable indicated **OR** conductor group of indicated cables, plus spares and blank positions adequate to suit specified expansion criteria, **as directed**.
    5. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
    6. Patch Cords: Factory-made, four-pair cables in **36-inch (900 mm) OR 48-inch (1200-mm), as directed**, lengths; terminated with eight-position modular plug at each end.
      - a. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
      - b. Patch cords shall have color-coded boots for circuit identification.
  - E. Optical Fiber Cable

1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**, -micrometer, 24-fiber, nonconductive, **as directed**, tight buffer, optical fiber cable.
    - a. Comply with ICEA S-83-596 for mechanical properties.
    - b. Comply with TIA/EIA-568-B.3 for performance specifications.
    - c. Comply with TIA/EIA-492AAAA-B **OR** TIA/EIA-492AAAA-A, **as directed**, for detailed specifications.
    - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
      - 1) General Purpose, Nonconductive: Type OFN or OFNG, or OFNR, OFNP, **as directed**.
      - 2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
      - 3) Riser Rated, Nonconductive: Type OFNR or OFNP, **as directed**, complying with UL 1666.
      - 4) General Purpose, Conductive: Type OFC or OFCG; or OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
      - 5) Plenum Rated, Conductive: Type OFCP or OFNP, **as directed**, complying with NFPA 262.
      - 6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **as directed**, complying with UL 1666.
    - e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
    - f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
    - g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
  2. Jacket:
    - a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
    - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
    - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm)**.
- F. Optical Fiber Cable Hardware
1. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.
    - a. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
  2. Patch Cords: Factory-made, dual-fiber cables in **36-inch (900-mm)** lengths.
  3. Cable Connecting Hardware:
    - a. Comply with Optical Fiber Connector Interchangeability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
    - b. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
    - c. Type SFF connectors may be used in termination racks, panels, and equipment packages.
- G. Coaxial Cable
1. Cable Characteristics: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
  2. RG-11/U: NFPA 70, Type CATV.
    - a. No. 14 AWG, solid, copper-covered steel conductor.
    - b. Gas-injected, foam-PE insulation.
    - c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
    - d. Jacketed with sunlight-resistant, black PVC or PE.
    - e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
  3. RG59/U: NFPA 70, Type CATVR.
    - a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
    - b. Gas-injected, foam-PE insulation.



- c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
    - d. Color-coded PVC jacket.
  - 4. RG-6/U: NFPA 70, Type CATV or CM.
    - a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
    - b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
    - c. Jacketed with black PVC or PE.
    - d. Suitable for indoor installations.
  - 5. RG59/U: NFPA 70, Type CATV.
    - a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
    - b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
    - c. PVC jacket.
  - 6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
    - a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
    - b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
    - c. Copolymer jacket.
  - 7. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
    - a. CATV Cable: Type CATV or CATVP or CATVR, **as directed**.
    - b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
    - c. CATV Riser Rated: Type CATVR; or CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
    - d. CATV Limited Rating: Type CATVX.
- H. Coaxial Cable Hardware
  - 1. Coaxial-Cable Connectors: Type BNC, 75 ohms.
- I. Consolidation Points
  - 1. Description: Consolidation points shall comply with requirements for cable connecting hardware.
    - a. Number of Terminals per Field: One for each conductor in assigned cables.
    - b. Number of Connectors per Field:
      - 1) One for each four-pair UTP cable indicated.
      - 2) One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
    - c. Mounting: Recessed in ceiling **OR** Wall **OR** Desk **OR** Furniture, **as directed**.
    - d. NRTL listed as complying with UL 50 and UL 1863.
    - e. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.
- J. Multiuser Telecommunications Outlet Assembly (MUTOA)
  - 1. Description: MUTOAs shall meet the requirements for cable connecting hardware.
    - a. Number of Terminals per Field: One for each conductor in assigned cables.
    - b. Number of Connectors per Field:
      - 1) One for each four-pair UTP cable indicated.
      - 2) One for each four-pair conductor group of indicated cables, plus 25 percent spare positions.
    - c. Mounting: Recessed in ceiling **OR** Wall **OR** Desk **OR** Furniture, **as directed**.
    - d. NRTL listed as complying with UL 50 and UL 1863.
    - e. Label shall include maximum length of work area cords, based on TIA/EIA-568-B.1.
    - f. When installed in plenums used for environmental air, NRTL listed as complying with UL 2043.
- K. Telecommunications Outlet/Connectors

1. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.
2. Workstation Outlets: Two **OR** Four, **as directed**, -port-connector assemblies mounted in single or multigang faceplate.
  - a. Plastic Faceplate: High-impact plastic. Coordinate color with Division 26 Section "Wiring Devices".
  - b. Metal Faceplate: Stainless steel **OR** Brass, **as directed**, complying with requirements in Division 26 Section "Wiring Devices".
  - c. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
    - 1) Flush mounting jacks, positioning the cord at a 45-degree angle.
  - d. Legend:
    - 1) Factory labeled by silk-screening or engraving for stainless steel **OR** brass, **as directed**, faceplates.  
**OR**  
Machine printed, in the field, using adhesive-tape label.  
**OR**  
Snap-in, clear-label covers and machine-printed paper inserts.

L. Grounding

1. Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems" for grounding conductors and connectors.
2. Comply with ANSI-J-STD-607-A.

M. Identification Products

1. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
2. Comply with requirements in Division 26 Section "Identification For Electrical Systems".

N. Cable Management System

1. Description: Computer-based cable management system, with integrated database and graphic, **as directed**, capabilities.
2. Document physical characteristics by recording the network, TIA/EIA details, and connections between equipment and cable.
3. Information shall be presented in database view, schematic plans, or technical drawings.
  - a. Microsoft Visio Professional or AutoCAD drawing software shall be used as drawing and schematic plans software.
4. System shall interface with the following testing and recording devices:
  - a. Direct upload tests from circuit testing instrument into the personal computer.
  - b. Direct download circuit labeling into labeling printer.

O. Source Quality Control

1. Testing Agency: Engage a qualified testing agency to evaluate cables.
2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
3. Factory test UTP cables according to TIA/EIA-568-B.2.
4. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.
5. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
6. Cable will be considered defective if it does not pass tests and inspections.
7. Prepare test and inspection reports.

### 1.3 EXECUTION

A. Entrance Facilities





1. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.
- B. Wiring Methods
  1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
    - a. Install plenum cable in environmental air spaces, including plenum ceilings.
    - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
  2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
  3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- C. Installation Of Pathways
  1. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
  2. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings". Drawings indicate general arrangement of pathways and fittings.
  3. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
  4. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
  5. Install manufactured conduit sweeps and long-radius elbows whenever possible.
  6. Pathway Installation in Communications Equipment Rooms:
    - a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
    - b. Install cable trays to route cables if conduits cannot be located in these positions.
    - c. Secure conduits to backboard when entering room from overhead.
    - d. Extend conduits **3 inches (76 mm)** above finished floor.
    - e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
  7. Backboards: Install backboards with **96-inch (2440-mm)** dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.
- D. Installation Of Cables
  1. Comply with NECA 1.
  2. General Requirements for Cabling:
    - a. Comply with TIA/EIA-568-B.1.
    - b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
    - c. Install 110-style IDC termination hardware unless otherwise indicated.
    - d. MUTOA shall not be used as a cross-connect point.
    - e. Consolidation points may be used only for making a direct connection to telecommunications outlet/connectors:
      - 1) Do not use consolidation point as a cross-connect point, as a patch connection, or for direct connection to workstation equipment.
      - 2) Locate consolidation points for UTP at least **49 feet (15 m)** from communications equipment room.
    - f. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.

- g. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- h. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
- i. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
- j. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- k. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
- l. In the communications equipment room, install a **10-foot- (3-m-)** long service loop on each end of cable.
- m. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
3. UTP Cable Installation:
  - a. Comply with TIA/EIA-568-B.2.
  - b. Do not untwist UTP cables more than **1/2 inch (12 mm)** from the point of termination to maintain cable geometry.
4. Optical Fiber Cable Installation:
  - a. Comply with TIA/EIA-568-B.3.
  - b. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
5. Open-Cable Installation:
  - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
  - b. Suspend UTP cable not in a wireway or pathway a minimum of **8 inches (200 mm)** above ceilings by cable supports not more than **60 inches (1524 mm)** apart.
  - c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
6. Installation of Cable Routed Exposed under Raised Floors:
  - a. Install plenum-rated cable only.
  - b. Install cabling after the flooring system has been installed in raised floor areas.
  - c. Coil cable **6 feet (1800 mm)** long not less than **12 inches (300 mm)** in diameter below each feed point.
7. Outdoor Coaxial Cable Installation:
  - a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
  - b. Attach antenna lead-in cable to support structure at intervals not exceeding **36 inches (915 mm)**.
8. Group connecting hardware for cables into separate logical fields.
9. Separation from EMI Sources:
  - a. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
  - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of **5 inches (127 mm)**.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **12 inches (300 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **24 inches (610 mm)**.
  - c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of **2-1/2 inches (64 mm)**.

- 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **6 inches (150 mm)**.
  - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **12 inches (300 mm)**.
  - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **3 inches (76 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **6 inches (150 mm)**.
  - e. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of **48 inches (1200 mm)**.
  - f. Separation between Communications Cables and Fluorescent Fixtures: A minimum of **5 inches (127 mm)**.
- E. Firestopping
1. Comply with requirements in Division 07 Section "Penetration Firestopping".
  2. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
  3. Comply with BICSI TDMM, "Firestopping Systems" Article.
- F. Grounding
1. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
  2. Comply with ANSI-J-STD-607-A.
  3. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least **2-inch (50-mm)** clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
  4. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
- G. Identification
1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
    - a. Administration Class: **1 OR 2 OR 3 OR 4, as directed**.
    - b. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
  2. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
  3. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
  4. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 **OR** Class 3 **OR** Class 4, **as directed**, level of administration, including optional identification requirements of this standard.
  5. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
  6. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and

equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by the Owner.

7. Cable and Wire Identification:

- a. Label each cable within **4 inches (100 mm)** of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
  - b. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
  - c. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding **15 feet (4.5 m)**.
  - d. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
    - 1) Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
    - 2) Label each unit and field within distribution racks and frames.
  - e. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
  - f. Uniquely identify and label work area cables extending from the MUTOA to the work area. These cables may not exceed the length stated on the MUTOA label.
8. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.
- a. Cables use flexible vinyl or polyester that flex as cables are bent.

H. Field Quality Control

1. Tests and Inspections:

- a. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
- b. Visually confirm Category 5e **OR** Category 6, **OR** Category 6e **as directed**, marking of outlets, cover plates, outlet/connectors, and patch panels.
- c. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
- d. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
  - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- e. Optical Fiber Cable Tests:
  - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
  - 2) Link End-to-End Attenuation Tests:
    - a) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
    - b) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
- f. UTP Performance Tests:

- 1) Test for each outlet and MUTOA. Perform the following tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.2:
  - a) Wire map.
  - b) Length (physical vs. electrical, and length requirements).
  - c) Insertion loss.
  - d) Near-end crosstalk (NEXT) loss.
  - e) Power sum near-end crosstalk (PSNEXT) loss.
  - f) Equal-level far-end crosstalk (ELFEXT).
  - g) Power sum equal-level far-end crosstalk (PSELFEXT).
  - h) Return loss.
  - i) Propagation delay.
  - j) Delay skew.
- g. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA/EIA-568-B.1 and TIA/EIA-568-B.3.
- h. Coaxial Cable Tests: Conduct tests according to Division 27 Section "Master Antenna Television System".
- i. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.
  - 1) Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
  - 2) Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
2. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
3. End-to-end cabling will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

END OF SECTION 26 05 19 16f

## SECTION 26 05 19 16g - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

### 1.1 GENERAL

#### A. Description of Work

1. This specification covers the furnishing and installation of materials for conductors and cables for electronic safety and security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. UTP cabling.
  - b. 50/125 and 62.5/125-micrometer, multimode optical fiber cabling.
  - c. Coaxial cabling.
  - d. RS-232 cabling.
  - e. RS-485 cabling.
  - f. Low-voltage control cabling.
  - g. Control-circuit conductors.
  - h. Fire alarm wire and cable.
  - i. Identification products.

#### C. Definitions

1. BICSI: Building Industry Consulting Service International.
2. EMI: Electromagnetic interference.
3. IDC: Insulation displacement connector.
4. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
5. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
6. RCDD: Registered Communications Distribution Designer.

#### D. Performance Requirements

1. Seismic Performance: Pathways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of product indicated.
  - a. For coaxial cable, include the following installation data for each type used:
    - 1) Nominal OD.
    - 2) Minimum bending radius.
    - 3) Maximum pulling tension.
2. Shop Drawings: Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:
  - a. Vertical and horizontal offsets and transitions.
  - b. Clearances for access above and to side of cable trays.
  - c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
3. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
4. Seismic Qualification Certificates: For pathways, accessories, and components, from manufacturer.



- a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
- b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 5. Source quality-control reports.
- 6. Field quality-control reports.
- 7. Operation and Maintenance Data: For wire and cable to include in operation and maintenance manuals. Include the following:
  - a. Allowable pulling tension of cable.
  - b. Cable connectors and terminations recommended by the manufacturer.

#### F. Quality Assurance

- 1. Testing Agency Qualifications: An NRTL.
  - a. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD **OR** possess the standards and experience for membership, **as directed**, to supervise on-site testing.
- 2. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
  - a. Flame-Spread Index: 25 or less.
  - b. Smoke-Developed Index: 50 **OR** 450, **as directed**, or less.
- 3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

#### G. Delivery, Storage, And Handling

- 1. Test cables upon receipt at Project site.
  - a. Test optical fiber cable to determine the continuity of the strand end to end. Use optical-fiber flashlight or optical loss test set.
  - b. Test optical fiber cable on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; include the loss value of each. Retain test data and include the record in maintenance data.
  - c. Test each pair of UTP cable for open and short circuits.

#### H. Project Conditions

- 1. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
  - a. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.
- 2. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

### 1.2 PRODUCTS

#### A. Pathways

- 1. Support of Open Cabling: NRTL labeled for support of Category 5e **OR** Category 6, **OR** Category 6e **as directed**, cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
  - a. Support brackets with cable tie slots for fastening cable ties to brackets.
  - b. Lacing bars, spools, J-hooks, and D-rings.
  - c. Straps and other devices.
- 2. Cable Trays:



- a. Cable Tray Materials: Metal, suitable for indoors, and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than **0.000472 inch (0.012 mm)** thick **OR** hot-dip galvanizing, complying with ASTM A 123/A 123M Grade 0.55, not less than **0.002165 inch (0.055 mm)** thick, **as directed**.
    - 1) Basket Cable Trays: **6 inches (150 mm)** wide and **2 inches (50 mm)** deep, **as directed**. Wire mesh spacing shall not exceed **2 by 4 inches (50 by 100 mm)**.
    - 2) Trough Cable Trays: Nominally **6 inches (150 mm)**, **as directed**, wide.
    - 3) Ladder Cable Trays: Nominally **18 inches (455 mm)**, **as directed**, wide, and a rung spacing of **12 inches (305 mm)**, **as directed**.
    - 4) Channel Cable Trays: One-piece construction, nominally **4 inches (100 mm)**, **as directed**, wide. Slot spacing shall not exceed **4-1/2 inches (115 mm)** o.c.
    - 5) Solid-Bottom Cable Trays: One-piece construction, nominally **12 inches (305 mm)**, **as directed**, wide. Provide with **OR** without, **as directed**, solid covers.
  3. Conduit and Boxes: Comply with requirements in Division 16 Section "Raceways and Boxes." Flexible metal conduit shall not be used, **as directed**.
  4. Outlet boxes shall be no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
- B. Backboards
1. Backboards: Plywood, fire-retardant treated, **as directed**, **3/4 by 48 by 96 inches (19 by 1220 by 2440 mm)**. Comply with requirements for plywood backing panels in Division 06 Section "Rough Carpentry".
- C. UTP Cable
1. Description: 100-ohm, 4-pair UTP, covered with a blue thermoplastic jacket.
    - a. Comply with ICEA S-90-661 for mechanical properties.
    - b. Comply with TIA/EIA-568-B.1 for performance specifications.
    - c. Comply with TIA/EIA-568-B.2, Category 5e **OR** Category 6, **OR** Category 6e **as directed**.
    - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
      - 1) Communications, General Purpose: Type CM or CMG; **OR** MPP, CMP, MPR, CMR, MP, or MPG, **as directed**.
      - 2) Communications, Plenum Rated: Type CMP **OR** MPP, **as directed**, complying with NFPA 262.
      - 3) Communications, Riser Rated: Type CMR; **OR** MPP, CMP, or MPR, **as directed**, complying with UL 1666.
      - 4) Communications, Limited Purpose: Type CMX; **OR** MPP, CMP, MPR, CMR, MP, MPG, CM, or CMG, **as directed**.
      - 5) Multipurpose: Type MP or MPG; **OR** MPP or MPR, **as directed**.
      - 6) Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
      - 7) Multipurpose, Riser Rated: Type MPR **OR** MPP, **as directed**, complying with UL 1666.
- D. UTP Cable Hardware
1. UTP Cable Connecting Hardware: IDC type, using modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of the same category or higher.
  2. Connecting Blocks: 110-style for Category 5e **OR** 110-style for Category 6 **OR** 66-style for Category 5e, **OR** 110-style for Category 6e **as directed**. Provide blocks for the number of cables terminated on the block, plus 25, **as directed**, percent spare. Integral with connector bodies, including plugs and jacks where indicated.
- E. Optical Fiber Cable
1. Description: Multimode, 50/125 **OR** 62.5/125, **as directed**,-micrometer, 24-fiber, **as directed**, nonconductive, **as directed**, tight buffer, optical fiber cable.

- a. Comply with ICEA S-83-596 for indoor cable OR ICEA S-87-640 for outside plant, as directed, for mechanical properties.
  - b. Comply with TIA/EIA-568-B.3 for performance specifications.
  - c. Comply with TIA-492AAAB OR TIA-492AAAA-A, **as directed**, for detailed specifications.
  - d. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
    - 1) General Purpose, Nonconductive: Type OFN or OFNG, **OR** OFNR, OFNP, **as directed**.
    - 2) Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
    - 3) Riser Rated, Nonconductive: Type OFNR or OFNP, complying with UL 1666.
    - 4) General Purpose, Conductive: Type OFC or OFCG; **OR** OFNG, OFN, OFCR, OFNR, OFCP, or OFNP, **as directed**.
    - 5) Plenum Rated, Conductive: Type OFCP or OFNP, complying with NFPA 262.
    - 6) Riser Rated, Conductive: Type OFCR; or OFNR, OFCP, or OFNP, **asa directed**, complying with UL 1666.
  - e. Conductive cable shall be steel **OR** aluminum, **as directed**, armored type.
  - f. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
  - g. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
2. Jacket:
- a. Jacket Color: Aqua for 50/125-micrometer cable **OR** Orange for 62.5/125-micrometer cable, **as directed**.
  - b. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-C.
  - c. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed **40 inches (1000 mm)**.
- F. Optical Fiber Cable Hardware
1. Cable Connecting Hardware: Meet the Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604-2-B, TIA-604-3-B, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
    - a. Quick-connect, simplex and duplex, Type SC **OR** Type ST **OR** Type LC **OR** Type MT-RJ, **as directed**, connectors. Insertion loss not more than 0.75 dB.
    - b. Type SFF connectors may be used in termination racks, panels, and equipment packages.
- G. Coaxial Cable
1. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.
  2. RG-11/U: NFPA 70, Type CATV.
    - a. No. 14 AWG, solid, copper-covered steel conductor.
    - b. Gas-injected, foam-PE insulation.
    - c. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
    - d. Jacketed with sunlight-resistant, black PVC or PE.
    - e. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C.
  3. RG59/U: NFPA 70, Type CATVR.
    - a. No. 20 AWG, solid, silver-plated, copper-covered steel conductor.
    - b. Gas-injected, foam-PE insulation.
    - c. Triple shielded with 100 percent aluminum polyester tape and 95 percent aluminum braid; covered by aluminum foil with grounding strip.
    - d. Color-coded PVC jacket.
  4. RG-6/U: NFPA 70, Type CATV or CM.
    - a. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
    - b. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
    - c. Jacketed with black PVC or PE.

- d. Suitable for indoor installations.
  - 5. RG59/U: NFPA 70, Type CATV.
    - a. No. 20 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
    - b. Double shielded with 100 percent aluminum polyester tape and 40 percent aluminum braid.
    - c. PVC jacket.
  - 6. RG59/U (Plenum Rated): NFPA 70, Type CMP.
    - a. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
    - b. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
    - c. Copolymer jacket.
  - 7. NFPA and UL Compliance: Coaxial cables shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655, and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:
    - a. CATV Cable: Type CATV, **OR** CATVP or CATVR, **as directed**.
    - b. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
    - c. CATV Riser Rated: Type CATVR; **OR** CATVP, CATVR, or CATV, **as directed**, complying with UL 1666.
    - d. CATV Limited Rating: Type CATVX.
- H. Coaxial Cable Hardware
  - 1. Coaxial-Cable Connectors: Type BNC, 75 ohms.
- I. RS-232 Cable
  - 1. Standard Cable: NFPA 70, Type CM.
    - a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
    - b. Polypropylene insulation.
    - c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
    - d. PVC jacket.
    - e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
    - f. Flame Resistance: Comply with UL 1581.
  - 2. Plenum-Rated Cable: NFPA 70, Type CMP.
    - a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
    - b. Plastic insulation.
    - c. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
    - d. Plastic jacket.
    - e. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
    - f. Flame Resistance: Comply with NFPA 262.
- J. RS-485 Cable
  - 1. Standard Cable: NFPA 70, Type CM **OR** CMG, **as directed**.
    - a. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
    - b. PVC insulation.
    - c. Unshielded.
    - d. PVC jacket.
    - e. Flame Resistance: Comply with UL 1581.
  - 2. Plenum-Rated Cable: NFPA 70, Type CMP.
    - a. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
    - b. Fluorinated ethylene propylene insulation.
    - c. Unshielded.
    - d. Fluorinated ethylene propylene jacket.
    - e. Flame Resistance: NFPA 262, Flame Test.
- K. Low-Voltage Control Cable



1. Paired Cable: NFPA 70, Type CMG.
    - a. 1 pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
    - b. PVC insulation.
    - c. Unshielded.
    - d. PVC jacket.
    - e. Flame Resistance: Comply with UL 1581.
  2. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
    - a. 1 pair, twisted, No. 16 AWG, stranded (19x29) and No. 18 AWG, stranded (19x30) tinned copper conductors.
    - b. PVC insulation.
    - c. Unshielded.
    - d. PVC jacket.
    - e. Flame Resistance: Comply with NFPA 262.
- L. Control-Circuit Conductors
1. Class 1 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway **OR** Type XHHN, complying with UL 44, in raceway, **as directed**.
  2. Class 2 Control Circuits: Stranded copper, Type THHN-THWN, complying with UL 83, in raceway **OR** power-limited cable, complying with UL 83, concealed in building finishes **OR** power-limited tray cable, complying with UL 83, in cable tray **OR** Type XHHN, complying with UL 44, in raceway, **as directed**.
  3. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or TF, complying with UL 83.
- M. Fire Alarm Wire And Cable
1. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
  2. Signaling Line Circuits: Twisted, shielded pair, not less than **OR** No. 18 AWG **OR** size as recommended by system manufacturer, **as directed**.
    - a. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.
  3. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
    - a. Low-Voltage Circuits: No. 16 AWG, minimum.
    - b. Line-Voltage Circuits: No. 12 AWG, minimum.
    - c. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with outer jacket, **as directed**, with red identifier stripe, NRTL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.
- N. Identification Products
1. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
  2. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
- O. Source Quality Control
1. Testing Agency: Engage a qualified testing agency to evaluate cables.
  2. Factory test UTP and optical fiber cables on reels according to TIA/EIA-568-B.1.
  3. Factory test UTP cables according to TIA/EIA-568-B.2.
  4. Factory test multimode optical fiber cables according to TIA-526-14-A and TIA/EIA-568-B.3.

5. Factory sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.
6. Cable will be considered defective if it does not pass tests and inspections.
7. Prepare test and inspection reports.

### 1.3 EXECUTION

#### A. Installation Of Pathways

1. Cable Trays: Comply with NEMA VE 2 and TIA-569-B.
2. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.
3. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
4. Install manufactured conduit sweeps and long-radius elbows whenever possible.
5. Pathway Installation in Equipment Rooms:
  - a. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
  - b. Install cable trays to route cables if conduits cannot be located in these positions.
  - c. Secure conduits to backboard when entering room from overhead.
  - d. Extend conduits **3 inches (75 mm)** above finished floor.
  - e. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
6. Backboards: Install backboards with **96-inch (2440-mm)** dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

#### B. Installation Of Hangers And Supports

1. Comply with requirements in Division 26 Section "Hangers And Supports For Electrical Systems" for installation of supports for pathways, conductors and cables.

#### C. Wiring Method

1. Install wiring in metal raceways and wireways. Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be **3/4 inch (21 mm)**. Control and data transmission wiring shall not share conduit with other building wiring systems.
2. Install wiring in raceways except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be **3/4 inch (21 mm)**. Control and data transmission wiring shall not share conduit with other building wiring systems.
3. Install cable, concealed in accessible ceilings, walls, and floors when possible.
4. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

#### D. Installation Of Conductors And Cables

1. Comply with NECA 1.
2. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.
3. General Requirements for Cabling:
  - a. Comply with TIA/EIA-568-B.1.
  - b. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."

- c. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
- d. Cables may not be spliced. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
- e. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
- f. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
- g. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
- h. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
4. UTP Cable Installation: Install using techniques, practices, and methods that are consistent with Category 5e **OR** Category 6, **OR** Category 6e **as directed**, rating of components and that ensure Category 5e **OR** Category 6, **OR** Category 6e **as directed**, performance of completed and linked signal paths, end to end.
  - a. Comply with TIA/EIA-568-B.2.
  - b. Install 110-style IDC termination hardware unless otherwise indicated.
  - c. Do not untwist UTP cables more than **1/2 inch (12 mm)** from the point of termination to maintain cable geometry.
5. Optical Fiber Cable Installation:
  - a. Comply with TIA/EIA-568-B.3.
  - b. Cable shall be terminated on connecting hardware that is rack or cabinet mounted.
6. Outdoor Coaxial Cable Installation:
  - a. Install outdoor connections in enclosures complying with NEMA 250, Type 4X. Install corrosion-resistant connectors with properly designed O-rings to keep out moisture.
  - b. Attach antenna lead-in cable to support structure at intervals not exceeding **36 inches (915 mm)**.
7. Open-Cable Installation:
  - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
  - b. Suspend copper cable not in a wireway or pathway a minimum of **8 inches (200 mm)** above ceilings by cable supports not more than **60 inches (1525 mm)** apart.
  - c. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
8. Installation of Cable Routed Exposed under Raised Floors:
  - a. Install plenum-rated cable only.
  - b. Install cabling after the flooring system has been installed in raised floor areas.
  - c. Coil cable **72 inches (1830 mm)** long shall be neatly coiled not less than **12 inches (300 mm)** in diameter below each feed point.
9. Separation from EMI Sources:
  - a. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
  - b. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of **5 inches (127 mm)**.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **12 inches (300 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **24 inches (600 mm)**.



- c. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: A minimum of **2-1/2 inches (64 mm)**.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **6 inches (150 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **12 inches (300 mm)**.
  - d. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
    - 1) Electrical Equipment Rating Less Than 2 kVA: No requirement.
    - 2) Electrical Equipment Rating between 2 and 5 kVA: A minimum of **3 inches (75 mm)**.
    - 3) Electrical Equipment Rating More Than 5 kVA: A minimum of **6 inches (150 mm)**.
  - e. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of **48 inches (1200 mm)**.
  - f. Separation between Cables and Fluorescent Fixtures: A minimum of **5 inches (127 mm)**.
- E. Fire Alarm Wiring Installation
1. Comply with NECA 1 and NFPA 72.
  2. Wiring Method: Install wiring in metal raceway according to Division 26 Section "Raceway And Boxes For Electrical Systems".
    - a. Install plenum cable in environmental air spaces, including plenum ceilings.
    - b. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
  3. Wiring Method:
    - a. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
    - b. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is **OR** is not, **as directed**, permitted.
    - c. Signaling Line Circuits: Power-limited fire alarm cables may **OR** shall not, **as directed**, be installed in the same cable or raceway as signaling line circuits.
  4. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
  5. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
  6. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
  7. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.
  8. Wiring to Remote Alarm Transmitting Device: **1-inch (25-mm)** conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function.
- F. Power And Control-Circuit Conductors
1. 120-V Power Wiring: Install according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables" unless otherwise indicated.
  2. Minimum Conductor Sizes:
    - a. Class 1 remote-control and signal circuits, No. 14 AWG.





- b. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
- c. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

G. Connections

- 1. Comply with requirements in Division 28 Section "Perimeter Security Systems" for connecting, terminating, and identifying wires and cables.
- 2. Comply with requirements in Division 28 Section "Intrusion Detection" for connecting, terminating, and identifying wires and cables.
- 3. Comply with requirements in Division 28 Section "Access Control" for connecting, terminating, and identifying wires and cables.
- 4. Comply with requirements in Division 28 Section "Video Surveillance" for connecting, terminating, and identifying wires and cables.
- 5. Comply with requirements in Division 28 Section "Plc Electronic Detention Monitoring And Control Systems" for connecting, terminating, and identifying wires and cables.
- 6. Comply with requirements in Division 28 Section(s) "Digital, Addressable Fire-alarm System" OR "Zoned (dc Loop) Fire-alarm System", **as directed**, for connecting, terminating, and identifying wires and cables.
- 7. Comply with requirements in Division 28 Section "Refrigerant Detection And Alarm" for connecting, terminating, and identifying wires and cables.

H. Firestopping

- 1. Comply with requirements in Division 07 Section "Penetration Firestopping".
- 2. Comply with TIA-569-B, "Firestopping" Annex A.
- 3. Comply with BICSI TDMM, "Firestopping Systems" Article.

I. Grounding

- 1. For communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- 2. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

J. Identification

- 1. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".

K. Field Quality Control

- 1. Perform tests and inspections.
- 2. Tests and Inspections:
  - a. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations to confirm color-coding for pin assignments, and inspect cabling connections to confirm compliance with TIA/EIA-568-B.1.
  - b. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
  - c. Test UTP cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross connection.
    - 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
  - d. Optical Fiber Cable Tests:

- 1) Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
- 2) Link End-to-End Attenuation Tests:
  - a) Multimode Link Measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526-14-A, Method B, One Reference Jumper.
  - b) Attenuation test results for links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
- e. Coaxial Cable Tests: Comply with requirements in Division 27 Section "Master Antenna Television System".
3. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
4. End-to-end cabling will be considered defective if it does not pass tests and inspections.
5. Prepare test and inspection reports.

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Task	Specification	Specification Description
26 05 19 16	01 22 16 00	No Specification Required
26 05 19 16	26 05 00 00	Common Work Results for Electrical
26 05 19 16	26 05 13 16	Conductors And Cables
26 05 19 16	26 05 13 16a	Undercarpet Cables
26 05 19 16	26 05 13 16b	Medium-Voltage Cables
26 05 23 00	26 05 19 16c	Control-Voltage Electrical Power Cables

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## SECTION 26 05 26 00 - LIGHTNING PROTECTION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for lightning protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes lightning protection for structures, structure elements and building site components.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For air terminals and mounting accessories.
  - a. Layout of the lightning protection system, along with details of the components to be used in the installation.
  - b. Include indications for use of raceway, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.
3. Qualification Data: For qualified Installer and manufacturer. Include data on listing or certification by UL.
4. Certification, signed by Contractor, that roof adhesive is approved by manufacturer of roofing material.
5. Field quality-control reports.
6. Comply with recommendations in NFPA 780, Annex D, "Inspection and Maintenance of Lightning Protection Systems," for maintenance of the lightning protection system.
7. Other Informational Submittals: Plans showing dimensioned as-built locations of grounding features, including the following:
  - a. Ground rods.
  - b. Ground loop conductor.

#### D. Quality Assurance

1. Installer Qualifications: Certified by UL or LPI as a Master Installer/Designer, trained and approved for installation of units required for this Project.
2. System Certificate:
  - a. UL Master Label.  
**OR**  
LPI System Certificate.  
**OR**  
UL Master Label Recertification.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 780, "Definitions" Article.

#### E. Coordination

1. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.
2. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.
3. Flashings of through-roof assemblies shall comply with roofing manufacturers' specifications.

## 1.2 PRODUCTS

- A. Lightning Protection System Components
1. Comply with UL 96 and NFPA 780, **as directed**.
  2. Roof-Mounted Air Terminals: NFPA 780, Class I **OR** Class II, **as directed**, aluminum **OR** copper, **as directed**, unless otherwise indicated.
    - a. Air Terminals More than **24 Inches (600 mm)** Long: With brace attached to the terminal at not less than half the height of the terminal.
    - b. Single-Membrane, Roof-Mounted Air Terminals: Designed specifically for single-membrane roof system materials. Comply with requirements in Division 07.
  3. Main and Bonding Conductors: Copper **OR** Aluminum, **as directed**.
  4. Ground Loop Conductor: The same size and type as the main conductor except tinned.
  5. Ground Rods: Copper-clad **OR** Zinc-coated **OR** Stainless, **as directed**, steel, sectional type, **as directed**; **3/4 inch (19 mm)** in diameter by **10 feet (3 m)** **OR** **5/8 inch (16 mm)** in diameter by **96 inches (2400 mm)**, **as directed**, long.
  6. Heavy-Duty, Stack-Mounted, Lightning Protection Components: Stainless steel **OR** Solid copper **OR** Monel metal **OR** Lead sheathed, **as directed**.

## 1.3 EXECUTION

- A. Installation
1. Install lightning protection components and systems according to UL 96A and NFPA 780.
  2. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends.
  3. Conceal the following conductors:
    - a. System conductors.
    - b. Down conductors.
    - c. Interior conductors.
    - d. Conductors within normal view of exterior locations at grade within **200 feet (60 m)** of building.
  4. Cable Connections: Use crimped or bolted connections for all conductor splices and connections between conductors and other components. Use exothermic-welded connections in underground portions of the system.  
**OR**  
Cable Connections: Use exothermic-welded connections for all conductor splices and connections between conductors and other components.
    - a. Exception: In single-ply membrane roofing, exothermic-welded connections may be used only below the roof level.
  5. Air Terminals on Single-Ply Membrane Roofing: Comply with roofing membrane and adhesive manufacturer's written instructions.
  6. Bond extremities of vertical metal bodies exceeding **60 feet (18 m)** in length to lightning protection components.
  7. Ground Loop: Install ground-level, potential equalization conductor and extend around the perimeter of structure **OR** area or item indicated, **as directed**.
    - a. Bury ground ring not less than **24 inches (600 mm)** from building foundation.
    - b. Bond ground terminals to the ground loop.
    - c. Bond grounded building systems to the ground loop conductor within **12 feet (3.6 m)** of grade level.
  8. Bond lightning protection components with intermediate-level interconnection loop conductors to grounded metal bodies of building at **60-foot (18-m)** intervals.
- B. Corrosion Protection
1. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.



2. Use conductors with protective coatings where conditions cause deterioration or corrosion of conductors.
- C. Field Quality Control
1. Notify the Owner at least 48 hours in advance of inspection before concealing lightning protection components.
  2. UL Inspection: Meet requirements to obtain a UL Master Label for system.  
**OR**  
LPI System Inspection: Meet requirements to obtain an LPI System Certificate.

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## SECTION 26 05 26 00a - GROUNDING AND BONDING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for grounding and bonding. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes methods and materials for grounding systems and equipment, plus the following special applications, **as directed**:
  - a. Overhead-lines grounding.
  - b. Underground distribution grounding.
  - c. Common ground bonding with lightning protection system.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Informational Submittals: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
  - a. Test wells.
  - b. Ground rods.
  - c. Ground rings.
  - d. Grounding arrangements and connections for separately derived systems.
  - e. Grounding for sensitive electronic equipment.
3. Qualification Data: For qualified testing agency and testing agency's field supervisor.
4. Field quality-control test reports.
5. Operation and Maintenance Data: For grounding to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data", include the following:
  - a. Instructions for periodic testing and inspection of grounding features at test wells **OR** ground rings **OR** grounding connections for separately derived systems, **as directed** based on NETA MTS **OR** NFPA 70B, **as directed**.
    - 1) Tests shall determine if ground-resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if values do not.
    - 2) Include recommended testing intervals.

#### D. Quality Assurance

1. Testing Agency Qualifications: Member company of NETA or an NRTL **OR** one who meets the requirements necessary for certification, **as directed**.
  - a. Testing Agency's Field Supervisor: Currently certified by NETA **OR** one who meets the requirements necessary for certification, **as directed**, to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with UL 467 for grounding and bonding materials and equipment.

### 1.2 PRODUCTS

#### A. Conductors

1. Insulated Conductors: Copper **OR** Tinned-copper, **as directed**, wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.



2. Bare Copper Conductors:
  - a. Solid Conductors: ASTM B 3.
  - b. Stranded Conductors: ASTM B 8.
  - c. Tinned Conductors: ASTM B 33.
  - d. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, **1/4 inch (6 mm)** in diameter.
  - e. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
  - f. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; **1-5/8 inches (41 mm)** wide and **1/16 inch (1.6 mm)** thick.
  - g. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; **1-5/8 inches (41 mm)** wide and **1/16 inch (1.6 mm)** thick.
3. Bare Grounding Conductor and Conductor Protector for Wood Poles:
  - a. No. 4 AWG minimum, soft-drawn copper.
  - b. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
4. Grounding Bus: Predrilled rectangular bars of annealed copper, **1/4 by 2 inches (6 by 50 mm)**, **as directed**, in cross section, with **9/32-inch (7.14-mm)** holes spaced **1-1/8 inches (28 mm)** apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

#### B. Connectors

1. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
2. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.
  - a. Pipe Connectors: Clamp type, sized for pipe.
3. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
4. Bus-bar Connectors: Mechanical type, cast silicon bronze, solderless compression **OR** exothermic-type wire terminals, **as directed**, and long-barrel, two-bolt connection to ground bus bar.

#### C. Grounding Electrodes

1. Ground Rods: Copper-clad **OR** Zinc-coated **OR** Stainless, **as directed**, steel, sectional type, **as directed**; **3/4 inch by 10 feet (19 mm by 3 m)** **OR** **5/8 by 96 inches (16 by 2400 mm)**, **as directed**, in diameter.
2. Chemical-Enhanced Grounding Electrodes: Copper tube, straight or L-shaped, charged with nonhazardous electrolytic chemical salts.
  - a. Termination: Factory-attached No. 4/0 AWG bare conductor at least **48 inches (1200 mm)** long.
  - b. Backfill Material: Electrode manufacturer's recommended material.

### 1.3 EXECUTION

#### A. Applications

1. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
2. Underground Grounding Conductors: Install bare copper **OR** tinned-copper, **as directed**, conductor, No. 2/0 AWG minimum. Bury at least **24 inches (600 mm)** below grade.
  - a. Bury at least **24 inches (600 mm)** below grade.
  - b. Duct-Bank Grounding Conductor: Bury **12 inches (300 mm)** above duct bank when indicated as part of duct-bank installation.

3. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
  4. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
    - a. Install bus on insulated spacers **1 inch (25 mm)**, minimum, from wall **6 inches (150 mm)** above finished floor, unless otherwise indicated.
    - b. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
  5. Conductor Terminations and Connections:
    - a. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
    - b. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
    - c. Connections to Ground Rods at Test Wells: Bolted connectors.
    - d. Connections to Structural Steel: Welded connectors.
- B. Grounding Overhead Lines
1. Comply with IEEE C2 grounding requirements.
  2. Install 2 parallel ground rods if resistance to ground by a single, ground-rod electrode exceeds 25 ohms.
  3. Drive ground rods until tops are **12 inches (300 mm)** below finished grade in undisturbed earth.
  4. Ground-Rod Connections: Install bolted connectors for underground connections and connections to rods.
  5. Lightning Arrester Grounding Conductors: Separate from other grounding conductors.
  6. Secondary Neutral and Transformer Enclosure: Interconnect and connect to grounding conductor.
  7. Protect grounding conductors running on surface of wood poles with molding extended from grade level up to and through communication service and transformer spaces.
- C. Grounding Underground Distribution System Components
1. Comply with IEEE C2 grounding requirements.
  2. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so **4 inches (100 mm)** will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from **2 inches (50 mm)** above to **6 inches (150 mm)** below concrete. Seal floor opening with waterproof, nonshrink grout.
  3. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields as recommended by manufacturer of splicing and termination kits.
  4. Pad-Mounted Transformers and Switches: Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than **6 inches (150 mm)** from the foundation.
- D. Equipment Grounding
1. Install insulated equipment grounding conductors with all feeders and branch circuits.
  2. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
    - a. Feeders and branch circuits.

- b. Lighting circuits.
  - c. Receptacle circuits.
  - d. Single-phase motor and appliance branch circuits.
  - e. Three-phase motor and appliance branch circuits.
  - f. Flexible raceway runs.
  - g. Armored and metal-clad cable runs.
  - h. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
  - i. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
  - j. X-Ray Equipment Circuits: Install insulated equipment grounding conductor in circuits supplying x-ray equipment.
3. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.
  4. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
  5. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
  6. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
  7. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.
    - a. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
    - b. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
  8. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

#### E. Installation

1. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.
2. Common Ground Bonding with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.
3. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.
  - a. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.

- b. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
  4. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Division 26 Section "Underground Ducts And Raceways For Electrical Systems" and shall be at least **12 inches (300 mm)** deep, with cover.
    - a. Test Wells: Install at least one test well for each service, unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
  5. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.
    - a. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
    - b. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
    - c. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
  6. Grounding and Bonding for Piping:
    - a. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
    - b. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
    - c. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
  7. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install tinned bonding jumper to bond across flexible duct connections to achieve continuity.
  8. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than **60 feet (18 m)** apart.
  9. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column **OR** indicated item, **as directed**, extending around the perimeter of building **OR** area or item indicated, **as directed**.
    - a. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
    - b. Bury ground ring not less than **24 inches (600 mm)** from building foundation.
  10. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of **20 feet (6 m)** of bare copper conductor not smaller than No. 4 AWG.
    - a. If concrete foundation is less than **20 feet (6 m)** long, coil excess conductor within base of foundation.
    - b. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

F. Labeling

1. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for instruction signs. The label or its text shall be green.
2. Install labels at the telecommunications bonding conductor and grounding equalizer and at the grounding electrode conductor where exposed.
  - a. Label Text: "If this connector or cable is loose or if it must be removed for any reason, notify the facility manager."





G. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Tests and Inspections:
  - a. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
  - b. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
    - 1) Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
    - 2) Perform tests by fall-of-potential method according to IEEE 81.
  - c. Prepare dimensioned drawings locating each test well, ground rod and ground rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
3. Report measured ground resistances that exceed the following values:
  - a. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
  - b. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
  - c. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
  - d. Power Distribution Units or Panelboards Serving Electronic Equipment: 1 **OR** 3, **as directed**, ohm(s).
  - e. Substations and Pad-Mounted Equipment: 5 ohms.
  - f. Manhole Grounds: 10 ohms.
4. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify the Owner promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26 00a



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Task	Specification	Specification Description
26 05 26 00	01 22 16 00	No Specification Required
26 05 26 00	02 84 33 00	Overhead Electrical Distribution

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## SECTION 26 05 29 00 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for hangers and supports for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Hangers and supports for electrical equipment and systems.
  - b. Construction requirements for concrete bases.

#### C. Definitions

1. EMT: Electrical metallic tubing.
2. IMC: Intermediate metal conduit.
3. RMC: Rigid metal conduit.

#### D. Performance Requirements

1. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
3. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
4. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

#### E. Submittals

1. Product Data: For the following:
  - a. Steel slotted support systems.
  - b. Nonmetallic slotted support systems.
2. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:
  - a. Trapeze hangers. Include Product Data for components.
  - b. Steel slotted channel systems. Include Product Data for components.
  - c. Nonmetallic slotted channel systems. Include Product Data for components.
  - d. Equipment supports.
3. Welding certificates.

#### F. Quality Assurance

1. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
2. Comply with NFPA 70.

### 1.2 PRODUCTS

#### A. Support, Anchorage, And Attachment Components



1. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
    - a. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
    - b. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
    - c. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
    - d. Channel Dimensions: Selected for applicable load criteria.
  2. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with **9/16-inch- (14-mm-)** diameter holes at a maximum of **8 inches (200 mm)** o.c., in at least 1 surface.
    - a. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
    - b. Fitting and Accessory Materials: Same as channels and angles, except metal items may be stainless steel.
    - c. Rated Strength: Selected to suit applicable load criteria.
  3. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
  4. Conduit and Cable Support Devices: Steel **OR** Steel and malleable-iron, **as directed**, hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
  5. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
  6. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
  7. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
    - a. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
    - b. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel **OR** stainless steel, **as directed**, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
    - c. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
    - d. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
    - e. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
    - f. Toggle Bolts: All-steel springhead type.
    - g. Hanger Rods: Threaded steel.
- B. Fabricated Metal Equipment Support Assemblies
1. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
  2. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

### 1.3 EXECUTION

#### A. Application

1. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
2. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by **OR** scheduled in NECA 1, where its Table 1 lists maximum

- spacings less than stated in, **as directed**, NFPA 70. Minimum rod size shall be **1/4 inch (6 mm)** in diameter.
3. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
    - a. Secure raceways and cables to these supports with two-bolt conduit clamps **OR** single-bolt conduit clamps **OR** single-bolt conduit clamps using spring friction action for retention in support channel, **as directed**.
  4. Spring-steel clamps designed for supporting single conduits without bolts may be used for **1-1/2-inch (38-mm)** and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.
- B. Support Installation
1. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
  2. Raceway Support Methods: In addition to methods described in NECA 1, EMT **OR** IMC **OR** RMC, **as directed**, may be supported by openings through structure members, as permitted in NFPA 70.
  3. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus **200 lb (90 kg)**.
  4. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
    - a. To Wood: Fasten with lag screws or through bolts.
    - b. To New Concrete: Bolt to concrete inserts.
    - c. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
    - d. To Existing Concrete: Expansion anchor fasteners.
    - e. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete **4 inches (100 mm)** thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than **4 inches (100 mm)** thick.
    - f. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts **OR** Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 **OR** Spring-tension clamps, **as directed**.
    - g. To Light Steel: Sheet metal screws.
    - h. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
  5. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.
- C. Installation Of Fabricated Metal Supports
1. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.
  2. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
  3. Field Welding: Comply with AWS D1.1/D1.1M.
- D. Concrete Bases
1. Construct concrete bases of dimensions indicated but not less than **4 inches (100 mm)** larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

2. Use **3000-psi (20.7-MPa)**, 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-place Concrete".
3. Anchor equipment to concrete base.
  - a. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - b. Install anchor bolts to elevations required for proper attachment to supported equipment.
  - c. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

E. Painting

1. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
  - a. Apply paint by brush or spray to provide minimum dry film thickness of **2.0 mils (0.05 mm)**.
2. Touchup: Comply with requirements in Division 07 OR Division 09 Section(s) "High-performance Coatings" **as directed**, for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
3. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29 00



## SECTION 26 05 29 00a - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for vibration and seismic controls for electrical systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Isolation pads.
  - b. Spring isolators.
  - c. Restrained spring isolators.
  - d. Channel support systems.
  - e. Restraint cables.
  - f. Hanger rod stiffeners.
  - g. Anchorage bushings and washers.

#### C. Definitions

1. The IBC: International Building Code.
2. ICC-ES: ICC-Evaluation Service.
3. OSHPD: Office of Statewide Health Planning and Development for the State of California.

#### D. Performance Requirements

1. Seismic-Restraint Loading:
  - a. Site Class as Defined in the IBC: **A OR B OR C OR D OR E OR F, as directed.**
  - b. Assigned Seismic Use Group or Building Category as Defined in the IBC: **I OR II OR III, as directed.**
    - 1) Component Importance Factor: **1.0 OR 1.5, as directed.**
    - 2) Component Response Modification Factor: **1.5 OR 2.5 OR 3.5 OR 5.0, as directed.**
    - 3) Component Amplification Factor: **1.0 OR 2.5, as directed.**
  - c. Design Spectral Response Acceleration at Short Periods (0.2 Second): As required to meet Project requirements.
  - d. Design Spectral Response Acceleration at 1.0-Second Period: As required to meet Project requirements.

#### E. Submittals

1. Product Data: For the following:
  - a. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
  - b. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
    - 1) Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed.**
    - 2) Annotate to indicate application of each product submitted and compliance with requirements.
  - c. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.
2. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

- a. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
  - 1) Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 22 for equipment mounted outdoors.
- b. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
- c. Field-fabricated supports.
- d. Seismic-Restraint Details:
  - 1) Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
  - 2) Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
  - 3) Preapproval and Evaluation Documentation: By an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, showing maximum ratings of restraint items and the basis for approval (tests or calculations).
- 3. Welding certificates.
- 4. Field quality-control test reports.

F. Quality Assurance

- 1. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- 2. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- 3. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- 4. Comply with NFPA 70.

## 1.2 PRODUCTS

A. Vibration Isolators

- 1. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
  - a. Resilient Material: Oil- and water-resistant neoprene **OR** rubber **OR** hermetically sealed compressed fiberglass, **as directed**.
- 2. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
  - a. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - b. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - c. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - d. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

- e. Baseplates: Factory drilled for bolting to structure and bonded to **1/4-inch- (6-mm-)** thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to **500 psig (3447 kPa)**.
- f. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- 3. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
  - a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to **1/4-inch- (6-mm-)** thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
  - b. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
  - c. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
  - d. Minimum Additional Travel: 50 percent of the required deflection at rated load.
  - e. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
  - f. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- B. Seismic-Restraint Devices
  - 1. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
    - a. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
  - 2. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
  - 3. Restraint Cables: ASTM A 603 galvanized-steel **OR** ASTM A 492 stainless-steel, **as directed**, cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
  - 4. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections **OR** Reinforcing steel angle clamped, **as directed**, to hanger rod. Do not weld stiffeners to rods.
  - 5. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.
  - 6. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.
  - 7. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
  - 8. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.
  - 9. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.
- C. Factory Finishes

1. Finish:
  - a. Manufacturer's standard prime-coat finish ready for field painting.
  - b. Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
    - 1) Powder coating on springs and housings.
    - 2) All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
    - 3) Baked enamel or powder coat for metal components on isolators for interior use.
    - 4) Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

### 1.3 EXECUTION

#### A. Applications

1. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**.
2. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.
3. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

#### B. Seismic-Restraint Device Installation

1. Equipment and Hanger Restraints:
  - a. Install restrained isolators on electrical equipment.
  - b. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds **0.125 inch (3.2 mm)**.
  - c. Install seismic-restraint devices using methods approved by an evaluation service member of ICC-ES **OR** OSHPD **OR** an agency acceptable to authorities having jurisdiction, **as directed**, providing required submittals for component.
2. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.
3. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
4. Drilled-in Anchors:
  - a. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
  - b. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
  - c. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
  - d. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
  - e. Set anchors to manufacturer's recommended torque, using a torque wrench.
  - f. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

- C. Accommodation Of Differential Seismic Motion
  - 1. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.
- D. Field Quality Control
  - 1. Tests and Inspections:
    - a. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
    - b. Schedule test with the Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
    - c. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
    - d. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
    - e. Test to 90 percent of rated proof load of device.
    - f. Measure isolator restraint clearance.
    - g. Measure isolator deflection.
    - h. Verify snubber minimum clearances.
    - i. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
  - 2. Remove and replace malfunctioning units and retest as specified above.
  - 3. Prepare test and inspection reports.
- E. Adjusting
  - 1. Adjust isolators after isolated equipment is at operating weight.
  - 2. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
  - 3. Adjust active height of spring isolators.
  - 4. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 26 05 29 00a

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Task	Specification	Specification Description
26 05 29 00	01 22 16 00	No Specification Required
26 05 29 00	05 12 23 00	Cold-Formed Metal Framing
26 05 29 00	05 50 00 00	Metal Fabrications
26 05 33 13	26 05 00 00	Common Work Results for Electrical
26 05 33 13	26 05 19 16	Common Work Results for Communications
26 05 33 13	26 05 19 16a	Common Work Results for Electronic Safety and Security
26 05 33 13	26 05 19 16b	Electrical Renovation
26 05 33 13	26 05 13 16	Conductors And Cables
26 05 33 13	26 05 19 16d	Communications Equipment Room Fittings
26 05 33 13	26 05 19 16e	Communications Backbone Cabling
26 05 33 13	26 05 19 16f	Communications Horizontal Cabling
26 05 33 13	26 05 19 16g	Conductors and Cables for Electronic Safety and Security





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## SECTION 26 05 33 16 - RACEWAYS AND BOXES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of raceways and boxes. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

#### C. Definitions

1. EMT: Electrical metallic tubing.
2. ENT: Electrical nonmetallic tubing.
3. EPDM: Ethylene-propylene-diene terpolymer rubber.
4. FMC: Flexible metal conduit.
5. IMC: Intermediate metal conduit.
6. LFMC: Liquidtight flexible metal conduit.
7. LFNC: Liquidtight flexible nonmetallic conduit.
8. NBR: Acrylonitrile-butadiene rubber.
9. RNC: Rigid nonmetallic conduit.

#### D. Submittals

1. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
2. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.
  - a. Custom enclosures and cabinets.
  - b. For handholes and boxes for underground wiring, including the following:
    - 1) Duct entry provisions, including locations and duct sizes.
    - 2) Frame and cover design.
    - 3) Grounding details.
    - 4) Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
    - 5) Joint details.
3. Samples: For each type of exposed finish required for wireways, nonmetallic wireways and surface raceways, prepared on Samples of size indicated below.
4. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
  - a. Structural members in the paths of conduit groups with common supports.
  - b. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.
5. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section(s) "Hangers And Supports For Electrical Systems" AND "Vibration And Seismic Controls For Electrical Systems". Include the following:
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - 1) The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."



- b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 6. Qualification Data: For professional engineer and testing agency.
- 7. Source quality-control test reports.

E. Quality Assurance

- 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- 2. Comply with NFPA 70.

## 1.2 PRODUCTS

A. Metal Conduit And Tubing

- 1. Rigid Steel Conduit: ANSI C80.1.
- 2. Aluminum Rigid Conduit: ANSI C80.5.
- 3. IMC: ANSI C80.6.
- 4. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit **OR** IMC, **as directed**.
  - a. Comply with NEMA RN 1.
  - b. Coating Thickness: **0.040 inch (1 mm)**, minimum.
- 5. EMT: ANSI C80.3.
- 6. FMC: Zinc-coated steel **OR** Aluminum **OR** Zinc-coated steel or aluminum, **as directed**.
- 7. LFMC: Flexible steel conduit with PVC jacket.
- 8. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
  - a. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
  - b. Fittings for EMT: Steel **OR** Die-cast, **as directed**, set-screw **OR** compression, **as directed**, type.
  - c. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, **0.040 inch (1 mm)**, with overlapping sleeves protecting threaded joints.
- 9. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

B. Nonmetallic Conduit And Tubing

- 1. ENT: NEMA TC 13.
- 2. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- 3. LFNC: UL 1660.
- 4. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- 5. Fittings for LFNC: UL 514B.

C. Optical Fiber/Communications Cable Raceway And Fittings

- 1. Description: Comply with UL 2024; flexible type, approved for plenum **OR** riser **OR** general-use, **as directed**, installation.

D. Metal Wireways

- 1. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 **OR** 12 **OR** 3R, **as directed**, unless otherwise indicated.
- 2. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

3. Wireway Covers: Hinged type **OR** Screw-cover type **OR** Flanged-and-gasketed type **OR** As indicated, **as directed**.
  4. Finish: Manufacturer's standard enamel finish.
- E. Nonmetallic Wireways
1. Description: Fiberglass polyester, extruded and fabricated to size and shape indicated, with no holes or knockouts. Cover is gasketed with oil-resistant gasket material and fastened with captive screws treated for corrosion resistance. Connections are flanged, with stainless-steel screws and oil-resistant gaskets.  
**OR**  
Description: PVC plastic, extruded and fabricated to size and shape indicated, with snap-on cover and mechanically coupled connections with plastic fasteners.
  2. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- F. Surface Raceways
1. Surface Metal Raceways: Galvanized steel with snap-on covers. Manufacturer's standard enamel finish in color selected **OR** Prime coating, ready for field painting, **as directed**.
  2. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected from manufacturer's standard **OR** custom, **as directed**, colors.
- G. Boxes, Enclosures, And Cabinets
1. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
  2. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy **OR** aluminum, **as directed**, Type FD, with gasketed cover.
  3. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
  4. Metal Floor Boxes: Cast metal **OR** Sheet metal, **as directed**, fully adjustable **OR** semi-adjustable, **as directed**, rectangular.
  5. Nonmetallic Floor Boxes: Nonadjustable, round.
  6. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
  7. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum **OR** galvanized, cast iron, **as directed**, with gasketed cover.
  8. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
    - a. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
    - b. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint, **as directed**.
  9. Cabinets:
    - a. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
    - b. Hinged door in front cover with flush latch and concealed hinge.
    - c. Key latch to match panelboards.
    - d. Metal barriers to separate wiring of different systems and voltage.
    - e. Accessory feet where required for freestanding equipment.
- H. Handholes And Boxes For Exterior Underground Wiring
1. Description: Comply with SCTE 77.
    - a. Color of Frame and Cover: Gray **OR** Green **as directed**.
    - b. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed**, bottom, unless otherwise indicated.
    - c. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
    - d. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
    - e. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** as indicated for each service, **as directed**.



- f. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
- g. Handholes **12 inches wide by 24 inches long (300 mm wide by 600 mm long)** and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.
2. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel or fiberglass or a combination of the two.
3. Fiberglass Handholes and Boxes with Polymer-Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester-resin enclosure joined to polymer-concrete top ring or frame.
4. Fiberglass Handholes and Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete **OR** reinforced concrete **OR** cast iron **OR** hot-dip galvanized-steel diamond plate **OR** fiberglass, **as directed**.

I. Sleeves For Raceways

1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
2. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
3. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum **0.052- or 0.138-inch (1.3- or 3.5-mm)** thickness as indicated and of length to suit application.
4. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".

J. Sleeve Seals

1. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
  - a. Sealing Elements: EPDM **OR** NBR, **as directed**, interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
  - b. Pressure Plates: Plastic **OR** Carbon steel **OR** Stainless steel, **as directed**. Include two for each sealing element.
  - c. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating **OR** Stainless steel, **as directed**, of length required to secure pressure plates to sealing elements. Include one for each sealing element.

K. Source Quality Control For Underground Enclosures

1. Handhole and Pull-Box Prototype Test: Test prototypes of handholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
  - a. Tests of materials shall be performed by a independent testing agency.
  - b. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
  - c. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

## 1.3 EXECUTION

A. Raceway Application

1. Outdoors: Apply raceway products as specified below, unless otherwise indicated:
  - a. Exposed Conduit: Rigid steel conduit **OR** IMC **OR** RNC, Type EPC-40-PVC **OR** RNC, Type EPC-80-PVC, **as directed**.
  - b. Concealed Conduit, Aboveground: Rigid steel conduit **OR** IMC **OR** EMT **OR** RNC, Type EPC-40-PVC, **as directed**.
  - c. Underground Conduit: RNC, Type EPC-40 **OR** 80, **as directed**, -PVC, direct buried.

- d. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LPMC **OR** LFNC, **as directed**.
- e. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R **OR** 4, **as directed**.
- f. Application of Handholes and Boxes for Underground Wiring:
  - 1) Handholes and Pull Boxes in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete **OR** Fiberglass enclosures with polymer-concrete frame and cover **OR** Fiberglass-reinforced polyester resin, **as directed**, SCTE 77, Tier 15 structural load rating.
  - 2) Handholes and Pull Boxes in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer-concrete units **OR** Heavy-duty fiberglass units with polymer-concrete frame and cover, **as directed**, SCTE 77, Tier 8 structural load rating.
  - 3) Handholes and Pull Boxes Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin, structurally tested according to SCTE 77 with **3000-lbf (13 345-N)** vertical loading.
2. Comply with the following indoor applications, unless otherwise indicated:
  - a. Exposed, Not Subject to Physical Damage: EMT **OR** ENT **OR** RNC, **as directed**.
  - b. Exposed, Not Subject to Severe Physical Damage: EMT **OR** RNC identified for such use, **as directed**.
  - c. Exposed and Subject to Severe Physical Damage: Rigid steel conduit **OR** IMC, **as directed**. Includes raceways in the following locations:
    - 1) Loading dock.
    - 2) Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
    - 3) Mechanical rooms.
  - d. Concealed in Ceilings and Interior Walls and Partitions: EMT **OR** ENT **OR** RNC, Type EPC-40-PVC, **as directed**.
  - e. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LPMC in damp or wet locations.
  - f. Damp or Wet Locations: Rigid steel conduit **OR** IMC, **as directed**.
  - g. Raceways for Optical Fiber or Communications Cable in Spaces Used for Environmental Air: Plenum-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
  - h. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: Riser-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
  - i. Raceways for Concealed General Purpose Distribution of Optical Fiber or Communications Cable: General-use, optical fiber/communications cable raceway **OR** Riser-type, optical fiber/communications cable raceway **OR** Plenum-type, optical fiber/communications cable raceway **OR** EMT, **as directed**.
  - j. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel **OR** nonmetallic, **as directed**, in damp or wet locations.
3. Minimum Raceway Size: **1/2-inch (16-mm) OR 3/4-inch (21-mm)**, **as directed**, trade size.
4. Raceway Fittings: Compatible with raceways and suitable for use and location.
  - a. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
  - b. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.
5. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.
6. Do not install aluminum conduits in contact with concrete.

**B. Installation**

1. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
2. Keep raceways at least **6 inches (150 mm)** away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

3. Complete raceway installation before starting conductor installation.
4. Support raceways as specified in Division 26 Section(s) "Hangers And Supports For Electrical Systems" AND "Vibration And Seismic Controls For Electrical Systems".
5. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
6. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
7. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
8. Raceways Embedded in Slabs:
  - a. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
  - b. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
  - c. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
9. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
10. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
11. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.
12. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:
  - a. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
  - b. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
  - c. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.
13. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:
  - a. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
  - b. Where otherwise required by NFPA 70.
14. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).
  - a. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
    - 1) Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) temperature change.
    - 2) Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
    - 3) Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
    - 4) Attics: 135 deg F (75 deg C) temperature change.
  - b. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.



- c. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.
  15. Flexible Conduit Connections: Use maximum of **72 inches (1830 mm)** of flexible conduit for recessed and semirecessed lighting fixtures, **as directed**, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
    - a. Use LFMC in damp or wet locations subject to severe physical damage.
    - b. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
  16. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.
  17. Set metal floor boxes level and flush with finished floor surface.
  18. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.
- C. Installation Of Underground Conduit
  1. Direct-Buried Conduit:
    - a. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than **6 inches (150 mm)** in nominal diameter.
    - b. Install backfill as specified in Division 31 Section "Earth Moving"
    - c. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within **12 inches (300 mm)** of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving".
    - d. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
 

**OR**

Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

      - 1) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with **3 inches (75 mm)** of concrete.

**OR**

For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of **60 inches (1500 mm)** from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
    - e. Warning Planks: Bury warning planks approximately **12 inches (300 mm)** above direct-buried conduits, placing them **24 inches (600 mm)** o.c. Align planks along the width and along the centerline of conduit.
- D. Installation Of Underground Handholes And Boxes
  1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
  2. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from **1/2-inch (12.5-mm)** sieve to **No. 4 (4.75-mm)** sieve and compacted to same density as adjacent undisturbed earth.
  3. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures **1 inch (25 mm)** above finished grade.
  4. Install handholes and boxes with bottom below the frost line, **<Insert depth of frost line below grade at Project site>** below grade.
  5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.



6. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

E. Sleeve Installation For Electrical Penetrations

1. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping".
2. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
3. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
4. Rectangular Sleeve Minimum Metal Thickness:
  - a. For sleeve cross-section rectangle perimeter less than **50 inches (1270 mm)** and no side greater than **16 inches (400 mm)**, thickness shall be **0.052 inch (1.3 mm)**.
  - b. For sleeve cross-section rectangle perimeter equal to, or greater than, **50 inches (1270 mm)** and 1 or more sides equal to, or greater than, **16 inches (400 mm)**, thickness shall be **0.138 inch (3.5 mm)**.
5. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
6. Cut sleeves to length for mounting flush with both surfaces of walls.
7. Extend sleeves installed in floors **2 inches (50 mm)** above finished floor level.
8. Size pipe sleeves to provide **1/4-inch (6.4-mm)** annular clear space between sleeve and raceway unless sleeve seal is to be installed or unless seismic criteria require different clearance.
9. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies, **as directed**.
10. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
11. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping".
12. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.
13. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for **1-inch (25-mm)** annular clear space between pipe and sleeve for installing mechanical sleeve seals.
14. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for **1-inch (25-mm)** annular clear space between raceway and sleeve for installing mechanical sleeve seals.

F. Sleeve-Seal Installation

1. Install to seal underground, exterior wall penetrations.
2. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

G. Firestopping

1. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping".

H. Protection

1. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Final Completion.

- a. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
- b. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33 16

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## SECTION 26 05 33 16a - WIRING DEVICES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of wiring devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Receptacles, receptacles with integral GFCI, and associated device plates.
  - b. Twist-locking receptacles.
  - c. Receptacles with integral surge suppression units.
  - d. Wall-box motion sensors.
  - e. Isolated-ground receptacles.
  - f. Hospital-grade receptacles.
  - g. Snap switches and wall-box dimmers.
  - h. Solid-state fan speed controls.
  - i. Wall-switch and exterior occupancy sensors.
  - j. Communications outlets.
  - k. Pendant cord-connector devices.
  - l. Cord and plug sets.
  - m. Floor service outlets, poke-through assemblies, service poles, and multioutlet assemblies.

#### C. Definitions

1. EMI: Electromagnetic interference.
2. GFCI: Ground-fault circuit interrupter.
3. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
4. RFI: Radio-frequency interference.
5. TVSS: Transient voltage surge suppressor.
6. UTP: Unshielded twisted pair.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.
3. Samples: One for each type of device and wall plate specified, in each color specified.
4. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

### 1.2 PRODUCTS

#### A. Straight Blade Receptacles

1. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.



2. Hospital-Grade, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498 Supplement SD.
  3. Isolated-Ground, Duplex Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
    - a. Description: Straight blade; equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
  4. Tamper-Resistant Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
    - a. Description: Labeled to comply with NFPA 70, "Health Care Facilities" Article, "Pediatric Locations" Section.
- B. GFCI Receptacles
1. General Description: Straight blade, feed **OR** non-feed, **as directed**, through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
  2. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
  3. Hospital-Grade, Duplex GFCI Convenience Receptacles, 125 V, 20 A: Comply with UL 498 Supplement SD.
- C. TVSS Receptacles
1. General Description: Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 1449, with integral TVSS in line to ground, line to neutral, and neutral to ground.
    - a. TVSS Components: Multiple metal-oxide varistors; with a nominal clamp-level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J, according to IEEE C62.41.2 and IEEE C62.45.
    - b. Active TVSS Indication: Visual and audible, with light visible in face of device to indicate device is "active" or "no longer in service."
  2. Duplex TVSS Convenience Receptacles:
    - a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.
  3. Isolated-Ground, Duplex Convenience Receptacles:
    - a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
  4. Hospital-Grade, Duplex Convenience Receptacles: Comply with UL 498 Supplement SD.
    - a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R.
  5. Isolated-Ground, Hospital-Grade, Duplex Convenience Receptacles:
    - a. Description: Straight blade, 125 V, 20 A; NEMA WD 6 configuration 5-20R. Comply with UL 498 Supplement SD. Equipment grounding contacts shall be connected only to the green grounding screw terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.
- D. Hazardous (Classified) Location Receptacles
1. Available Wiring Devices for Hazardous (Classified) Locations: Comply with NEMA FB 11 and UL 1010.
- E. Twist-Locking Receptacles
1. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498.
  2. Isolated-Ground, Single Convenience Receptacles, 125 V, 20 A:
    - a. Description: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Equipment grounding contacts shall be connected only to the green grounding screw

terminal of the device and with inherent electrical isolation from mounting strap. Isolation shall be integral to receptacle construction and not dependent on removable parts.

F. Pendant Cord-Connector Devices

1. Description: Matching, locking-type plug and receptacle body connector; NEMA WD 6 configurations L5-20P and L5-20R, heavy-duty grade.
  - a. Body: Nylon with screw-open cable-gripping jaws and provision for attaching external cable grip.
  - b. External Cable Grip: Woven wire-mesh type made of high-strength galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

G. Cord And Plug Sets

1. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
  - a. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
  - b. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

H. Snap Switches

1. Comply with NEMA WD 1 and UL 20.
2. Switches, 120/277 V, 20 A:
3. Pilot Light Switches, 20 A:
  - a. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
4. Key-Operated Switches, 120/277 V, 20 A:
  - a. Description: Single pole, with factory-supplied key in lieu of switch handle.
5. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.
6. Key-Operated, Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors, with factory-supplied key in lieu of switch handle.

I. Wall-Box Dimmers

1. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.
2. Control: Continuously adjustable slider **OR** toggle switch **OR** rotary knob, **as directed**; with single-pole or three-way switching. Comply with UL 1472.
3. Incandescent Lamp Dimmers: 120 V; control shall follow square-law dimming curve. On-off switch positions shall bypass dimmer module.
  - a. 600 W; dimmers shall require no derating when ganged with other devices. Illuminated when "OFF," **as directed**.
4. Fluorescent Lamp Dimmer Switches: Modular; compatible with dimmer ballasts; trim potentiometer to adjust low-end dimming; dimmer-ballast combination capable of consistent dimming with low end not greater than 20 percent of full brightness.

J. Fan Speed Controls

1. Modular, 120-V, full-wave, solid-state units with integral, quiet on-off switches and audible frequency and EMI/RFI filters. Comply with UL 1917.
  - a. Continuously adjustable slider **OR** toggle switch **OR** rotary knob, **as directed**, 5 A **OR** 1.5 A, **as directed**.
  - b. Three-speed adjustable slider **OR** rotary knob, **as directed**, 1.5 A.

K. Occupancy Sensors

1. Wall-Switch Sensors:



- a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 180-degree field of view, with a minimum coverage area of **900 sq. ft. (84 sq. m).**
  2. Wall-Switch Sensors:
    - a. Description: Adaptive-technology type, 120/277 V, adjustable time delay up to 20 minutes, 180-degree field of view, with a minimum coverage area of **900 sq. ft. (84 sq. m).**
  3. Long-Range Wall-Switch Sensors:
    - a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, with a minimum coverage area of **1200 sq. ft. (111 sq. m).**
  4. Long-Range Wall-Switch Sensors:
    - a. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area of **1200 sq. ft. (111 sq. m).**
  5. Wide-Range Wall-Switch Sensors:
    - a. Description: Passive-infrared type, 120/277 V, adjustable time delay up to 30 minutes, 150-degree field of view, with a minimum coverage area of **1200 sq. ft. (111 sq. m).**
  6. Exterior Occupancy Sensors:
    - a. Description: Passive-infrared type, 120/277 V, weatherproof, adjustable time delay up to 15 minutes, 180-degree field of view, and **110-foot (34-m)** detection range. Minimum switch rating: 1000-W incandescent, 500-VA fluorescent.
- L. Communications Outlets
  1. Telephone Outlet:
    - a. Description: Single RJ-45 jack for terminating 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e. Comply with UL 1863.
  2. Combination TV and Telephone Outlet:
    - a. Description: Single RJ-45 jack for 100-ohm, balanced, four-pair UTP; TIA/EIA-568-B.1; complying with Category 5e; and one Type F coaxial cable connector.
- M. Wall Plates
  1. Single and combination types to match corresponding wiring devices.
    - a. Plate-Securing Screws: Metal with head color to match plate finish.
    - b. Material for Finished Spaces: Steel with white baked enamel, suitable for field painting **OR** Smooth, high-impact thermoplastic **OR** **0.035-inch- (1-mm-)** thick, satin-finished stainless steel **OR** **0.04-inch- (1-mm-)** thick, brushed brass with factory polymer finish **OR** **0.05-inch- (1.2-mm-)** thick anodized aluminum **OR** **0.04-inch- (1-mm-)** thick steel with chrome-plated finish, **as directed**.
    - c. Material for Unfinished Spaces: Galvanized steel **OR** Smooth, high-impact thermoplastic, **as directed**.
    - d. Material for Damp Locations: Thermoplastic **OR** Cast aluminum, **as directed**, with spring-loaded lift cover, and listed and labeled for use in "wet locations."
  2. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant, die-cast aluminum **OR** thermoplastic, **as directed**, with lockable cover.
- N. Floor Service Fittings
  1. Type: Modular, flush-type **OR** flap-type **OR** above-floor, **as directed**, dual-service units suitable for wiring method used.
  2. Compartments: Barrier separates power from voice and data communication cabling.
  3. Service Plate: Rectangular **OR** Round, **as directed**, die-cast aluminum **OR** solid brass, **as directed**, with satin finish.
  4. Power Receptacle: NEMA WD 6 configuration 5-20R, gray finish, unless otherwise indicated.
  5. Voice and Data Communication Outlet: Blank cover with bushed cable opening **OR** Two modular, keyed, color-coded, RJ-45 Category 5e jacks for UTP cable, **as directed**.
- O. Poke-Through Assemblies

1. Description: Factory-fabricated and -wired assembly of below-floor junction box with multichanneled, through-floor raceway/firestop unit and detachable matching floor service outlet assembly.
  - a. Service Outlet Assembly: Pedestal type with services indicated **OR** Flush type with two simplex receptacles and space for two RJ-45 jacks **OR** Flush type with four simplex receptacles and space for four RJ-45 jacks, **as directed**.
  - b. Size: Selected to fit nominal **3-inch (75-mm) OR 4-inch (100-mm)**, **as directed**, cored holes in floor and matched to floor thickness.
  - c. Fire Rating: Unit is listed and labeled for fire rating of floor-ceiling assembly.
  - d. Closure Plug: Arranged to close unused **3-inch (75-mm) OR 4-inch (100-mm)**, **as directed**, cored openings and reestablish fire rating of floor.
  - e. Wiring Raceways and Compartments: For a minimum of four No. 12 AWG conductors and a minimum of two **OR** four, **as directed**, 4-pair, Category 5e voice and data communication cables.

P. Multioutlet Assemblies

1. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.
2. Raceway Material: Metal, with manufacturer's standard finish **OR** PVC, **as directed**.
3. Wire: No. 12 AWG.

Q. Service Poles

1. Description: Factory-assembled and -wired units to extend power and voice and data communication from distribution wiring concealed in ceiling to devices or outlets in pole near floor.
  - a. Poles: Nominal **2.5-inch- (65-mm-)** square cross section, with height adequate to extend from floor to at least **6 inches (150 mm)** above ceiling, and with separate channels for power wiring and voice and data communication cabling.
  - b. Mounting: Ceiling trim flange with concealed bracing arranged for positive connection to ceiling supports; with pole foot and carpet pad attachment.
  - c. Finishes: Manufacturer's standard painted finish and trim combination **OR** Satin-anodized aluminum, **as directed**.
  - d. Wiring: Sized for minimum of five No. 12 AWG power and ground conductors and a minimum of four, 4-pair, Category 3 or 5 voice and data communication cables.
  - e. Power Receptacles: Two duplex, 20-A, heavy-duty, NEMA WD 6 configuration 5-20R units.
  - f. Voice and Data Communication Outlets: Blank insert with bushed cable opening **OR** Two RJ-45 Category 5e jacks **OR** Four RJ-45 Category 5e jacks, **as directed**.

R. Finishes

1. Color: Wiring device catalog numbers in Section Text do not designate device color.
  - a. Wiring Devices Connected to Normal Power System: Almond **OR** Black **OR** Brown **OR** Gray **OR** Ivory **OR** White **OR** As selected, **as directed**, unless otherwise indicated or required by NFPA 70 or device listing.
  - b. Wiring Devices Connected to Emergency Power System: Red.
  - c. TVSS Devices: Blue.
  - d. Isolated-Ground Receptacles: Orange **OR** As specified above, with orange triangle on face, **as directed**.

### 1.3 EXECUTION

A. Installation

1. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
2. Coordination with Other Trades:

- a. Take steps to insure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
  - b. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
  - c. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
  - d. Install wiring devices after all wall preparation, including painting, is complete.
3. Conductors:
  - a. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
  - b. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
  - c. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
  - d. Existing Conductors:
    - 1) Cut back and pigtail, or replace all damaged conductors.
    - 2) Straighten conductors that remain and remove corrosion and foreign matter.
    - 3) Pigtailing existing conductors is permitted provided the outlet box is large enough.
4. Device Installation:
  - a. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
  - b. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
  - c. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
  - d. Connect devices to branch circuits using pigtails that are not less than **6 inches (152 mm)** in length.
  - e. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
  - f. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
  - g. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
  - h. Tighten unused terminal screws on the device.
  - i. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
5. Receptacle Orientation:
  - a. Install ground pin of vertically mounted receptacles up **OR** down, **as directed**, and on horizontally mounted receptacles to the right **OR** left, **as directed**.
  - b. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
6. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.
7. Dimmers:
  - a. Install dimmers within terms of their listing.
  - b. Verify that dimmers used for fan speed control are listed for that application.
  - c. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.
8. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multigang wall plates.
9. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

B. Identification

1. Comply with Division 26 Section "Identification For Electrical Systems".
  - a. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black **OR** white **OR** red, **as directed**, -filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
  - a. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
  - b. Test Instruments: Use instruments that comply with UL 1436.
  - c. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.
2. Tests for Convenience Receptacles:
  - a. Line Voltage: Acceptable range is 105 to 132 V.
  - b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
  - c. Ground Impedance: Values of up to 2 ohms are acceptable.
  - d. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
  - e. Using the test plug, verify that the device and its outlet box are securely mounted.
  - f. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
3. Test straight blade convenience outlets in patient-care areas **OR** hospital-grade convenience outlets, **as directed**, for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. (115 g).

END OF SECTION 26 05 33 16a

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Task	Specification	Specification Description
26 05 33 16	26 05 19 16b	Electrical Renovation
26 05 33 23	26 05 33 16	Raceways And Boxes
26 05 33 23	26 05 19 13	Underfloor Raceways For Electrical Systems

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## SECTION 26 05 36 00 - CABLE TRAYS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of cable trays. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes steel, aluminum, stainless-steel, and fiberglass cable trays and accessories.

#### C. Submittals

1. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
2. Shop Drawings: For each type of cable tray.
  - a. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
  - b. Seismic-Restraint Details, **as directed**: Signed and sealed by a qualified professional engineer, licensed in the state where Project is located, who is responsible for their preparation.
    - 1) Design Calculations: Calculate requirements for selecting seismic restraints.
    - 2) Detail fabrication, including anchorages and attachments to structure and to supported cable trays.
3. Field quality-control reports.
4. Operation and Maintenance Data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

#### E. Delivery, Storage, And Handling

1. Steel cable tray, hot dip galvanized after fabrication, **OR** Aluminum cable tray **OR** Stainless-steel cable tray **OR** Fiberglass cable tray, **as directed** may be stored outside without cover, but shall be loosely stacked, elevated off the ground, and ventilated to prevent staining during storage.
2. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.
3. Steel, mill galvanized **OR** electrogalvanized **OR** factory-primed, **as directed**, cable tray shall be stored in a well-ventilated, dry location. Unpack and dry wet materials before storage.
4. PVC-coated **OR** Field-painted, **as directed**, cable tray shall be stored indoors. Protect cable tray from scratching and marring of finish. Unpack and dry wet materials before storage.

### 1.2 PRODUCTS

#### A. Materials And Finishes

1. Cable Trays, Fittings, and Accessories: Steel, complying with NEMA VE 1.



- a. Factory-standard primer, ready for field painting; with cadmium-plated hardware according to ASTM B 766.
  - b. Mill galvanized before fabrication, complying with ASTM A 653/A 653M, **G90 (Z275)** coating; with hardware galvanized according to ASTM B 633 **OR** cadmium plated according to ASTM B 766, **as directed**.
  - c. Electrogalvanized before fabrication, complying with ASTM B 633; with hardware galvanized according to ASTM B 633.
  - d. Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M, Class B2; with chromium-zinc, ASTM F 1136, **OR** Type 316 stainless-steel, **as directed**, hardware.
  - e. PVC coating applied in a fluidized bed or by electrostatic spray; with chromium-zinc, ASTM F 1136 **OR** Type 316 stainless-steel, **as directed**, hardware.
  - f. Epoxy-resin paint over paint manufacturer's recommended primer and corrosion-inhibiting treatment; with cadmium-plated hardware according to ASTM B 766 **OR** Type 316 stainless-steel hardware, **as directed**.
2. Cable Trays, Fittings, and Accessories: Aluminum, complying with NEMA VE 1, Aluminum Association's Alloy 6063-T6 for rails, rungs, and cable trays, and Alloy 5052-H32 or Alloy 6061-T6 for fabricated parts; with chromium-zinc, ASTM F 1136, **OR** Type 316 stainless-steel, **as directed**, splice-plate fasteners, bolts, and screws
  3. Cable Trays, Fittings, and Accessories: Stainless steel, Type 304 **OR** 316, **as directed**, complying with NEMA VE 1.
  4. Cable Trays, Fittings, and Accessories: Fiberglass, complying with NEMA FG 1 and UL 568. Splice-plate fasteners, bolts, and screws shall be fiberglass-encapsulated stainless steel. Design fasteners so that no metal is visible when fully assembled and tightened. Fastener encapsulation shall not be damaged when torqued to manufacturer's recommended value.
  5. Sizes and Configurations: Refer to the Cable Tray Schedule on Drawings for specific requirements for types, materials, sizes, and configurations.
    - a. Center-hanger supports may be used only when specifically indicated.

B. Cable Tray Accessories

1. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
2. Covers: Solid **OR** Louvered **OR** Ventilated-hat **OR** 2-in-3 pitch cover, **as directed**, type of same materials and finishes as cable tray.
3. Barrier Strips: Same materials and finishes as cable tray.
4. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

C. Warning Signs

1. Lettering: **1-1/2-inch- (40-mm-)** high, black letters on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
2. Materials and fastening are specified in Division 26 Section "Identification For Electrical Systems".

### 1.3 EXECUTION

A. Cable Tray Installation

1. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support systems, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.
2. Remove burrs and sharp edges from cable trays.
3. Fasten cable tray supports to building structure and install seismic restraints, **as directed**.

- a. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
  - b. Place supports so that spans do not exceed maximum spans on schedules.
  - c. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
  - d. Support bus assembly to prevent twisting from eccentric loading.
  - e. Manufacture center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
  - f. Locate and install supports according to NEMA FG 1 **OR** NEMA VE 1, **as directed**.
  4. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
  5. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed dimensions recommended in NEMA FG 1 **OR** NEMA VE 1, **as directed**. Space connectors and set gaps according to applicable standard.
  6. Make changes in direction and elevation using standard fittings.
  7. Make cable tray connections using standard fittings.
  8. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping".
  9. Sleeves for Future Cables: Install capped sleeves for future cables through firestop-sealed cable tray penetrations of fire and smoke barriers.
  10. Workspace: Install cable trays with enough space to permit access for installing cables.
  11. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15 000 V.
  12. After installation of cable trays is completed, install warning signs in visible locations on or near cable trays.
- B. Cable Installation
1. Install cables only when cable tray installation has been completed and inspected.
  2. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
  3. On vertical runs, fasten cables to tray every **18 inches (457 mm)**. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
  4. In existing construction, remove inactive or dead cables from cable tray.
  5. Install covers after installation of cable is completed.
- C. Connections
1. Ground cable trays according to manufacturer's written instructions.
  2. Install an insulated equipment grounding conductor with cable tray, in addition to those required by NFPA 70.
- D. Field Quality Control
1. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
    - a. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
    - b. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
    - c. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.



- d. Remove deposits of dust, industrial process materials, trash of any description, and any blockage of tray ventilation.
  - e. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorquer in suspect areas.
  - f. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
  - g. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.
2. Report results in writing.

E. Protection

1. Protect installed cable trays.
  - a. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
  - b. Repair damage to PVC or paint finishes with matching touchup coating recommended by cable tray manufacturer.
  - c. Install temporary protection for cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION 26 05 36 00



Task	Specification	Specification Description
26 05 39 00	26 05 19 13	Underfloor Raceways For Electrical Systems
26 05 43 00	26 05 00 00	Common Work Results for Electrical
26 05 43 00	26 05 19 16	Common Work Results for Communications
26 05 43 00	26 05 19 16a	Common Work Results for Electronic Safety and Security
26 05 43 00	26 05 19 16d	Communications Equipment Room Fittings
26 05 43 00	26 05 19 16e	Communications Backbone Cabling
26 05 43 00	26 05 19 16f	Communications Horizontal Cabling
26 05 43 00	26 05 19 16g	Conductors and Cables for Electronic Safety and Security
26 05 46 00	02 84 33 00	Overhead Electrical Distribution

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## SECTION 26 05 53 00 - ELECTRICAL IDENTIFICATION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for electrical identification. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Identification for raceways.
  - b. Identification of power and control cables.
  - c. Identification for conductors.
  - d. Underground-line warning tape.
  - e. Warning labels and signs.
  - f. Instruction signs.
  - g. Equipment identification labels.
  - h. Miscellaneous identification products.

#### C. Submittals

1. Product Data: For each electrical identification product indicated.
2. Samples: For each type of label and sign to illustrate size, colors, lettering style, mounting provisions, and graphic features of identification products.
3. Identification Schedule: An index of nomenclature of electrical equipment and system components used in identification signs and labels.

#### D. Quality Assurance

1. Comply with ANSI A13.1 and IEEE C2, **as directed**.
2. Comply with NFPA 70.
3. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
4. Comply with ANSI Z535.4 for safety signs and labels.
5. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

### 1.2 PRODUCTS

#### A. Power Raceway Identification Materials

1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway size.
2. Colors for Raceways Carrying Circuits at 600 V or Less:
  - a. Black letters on an orange field.
  - b. Legend: Indicate voltage and system or service type, **as directed**.
3. Colors for Raceways Carrying Circuits at More Than 600 V:
  - a. Black letters on an orange field.
  - b. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high letters on 20-inch (500-mm) centers.
4. Self-Adhesive Vinyl Labels for Raceways Carrying Circuits at 600 V or Less: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.





5. Snap-Around Labels for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
  6. Snap-Around, Color-Coding Bands for Raceways Carrying Circuits at 600 V or Less: Slit, pretensioned, flexible, solid-colored acrylic sleeve, **2 inches (50 mm)** long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
  7. Tape and Stencil for Raceways Carrying Circuits More Than 600 V: **4-inch- (100-mm-)** wide black stripes on **10-inch (250-mm)** centers diagonally over orange background that extends full length of raceway or duct and is **12 inches (300 mm)** wide. Stop stripes at legends.
  8. Metal Tags: Brass or aluminum, **2 by 2 by 0.05 inch (50 by 50 by 1.3 mm)**, with stamped legend, punched for use with self-locking cable tie fastener.
  9. Write-On Tags: Polyester tag, **0.010 inch (0.25 mm) OR 0.015 inch (0.38 mm)**, **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
    - a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
    - OR**
    - Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- B. Armored And Metal-Clad Cable Identification Materials
1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
  2. Colors for Raceways Carrying Circuits at 600 V and Less:
    - a. Black letters on an orange field.
    - b. Legend: Indicate voltage and system or service type, **as directed**.
  3. Colors for Raceways Carrying Circuits at More Than 600 V:
    - a. Black letters on an orange field.
    - b. Legend: "DANGER CONCEALED HIGH VOLTAGE WIRING" with **3-inch- (75-mm-)** high letters on **20-inch (500-mm)** centers.
  4. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
 

**OR**

Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; **2 inches (50 mm)** wide; compounded for outdoor use.
- C. Power And Control Cable Identification Materials
1. Comply with ANSI A13.1 for minimum size of letters for legend and for minimum length of color field for each raceway and cable size.
  2. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
  3. Metal Tags: Brass or aluminum, **2 by 2 by 0.05 inch (50 by 50 by 1.3 mm)**, with stamped legend, punched for use with self-locking cable tie fastener.
  4. Write-On Tags: Polyester tag, **0.010 inch (0.25 mm) OR 0.015 inch (0.38 mm)**, **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
    - a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.
    - OR**
    - Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
  5. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.

6. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, **2 inches (50 mm)** long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
- D. Conductor Identification Materials
1. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than **3 mils (0.08 mm)** thick by **1 to 2 inches (25 to 50 mm)** wide.
  2. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.
  3. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
  4. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve, **2 inches (50 mm)** long, with diameter sized to suit diameter of raceway or cable it identifies and to stay in place by gripping action.
  5. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.
  6. Write-On Tags: Polyester tag, **0.010 inch (0.25 mm)** **OR** **0.015 inch (0.38 mm)**, **as directed**, thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.
    - a. Marker for Tags: Permanent, waterproof, black ink marker recommended by tag manufacturer.  
**OR**  
Marker for Tags: Machine-printed, permanent, waterproof, black ink marker recommended by printer manufacturer.
- E. Floor Marking Tape
1. **2-inch- (50-mm-)** wide, **5-mil (0.125-mm)** pressure-sensitive vinyl tape, with black and white stripes and clear vinyl overlay.
- F. Underground-Line Warning Tape
1. Tape:
    - a. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
    - b. Printing on tape shall be permanent and shall not be damaged by burial operations.
    - c. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
  2. Color and Printing:
    - a. Comply with ANSI Z535.1 through ANSI Z535.5.
    - b. Inscriptions for Red-Colored Tapes: **ELECTRIC LINE, HIGH VOLTAGE.**
    - c. Inscriptions for Orange-Colored Tapes: **TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE.**
  3. Tag: Type I:
    - a. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
    - b. Thickness: **4 mils (0.1 mm).**
    - c. Weight: **18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).**
    - d. **3-Inch (75-mm)** Tensile According to ASTM D 882: **30 lbf (133.4 N)**, and **2500 psi (17.2 MPa).**
  4. Tag: Type II:
    - a. Multilayer laminate consisting of high-density polyethylene scrim coated with pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
    - b. Thickness: **12 mils (0.3 mm).**
    - c. Weight: **36.1 lb/1000 sq. ft. (17.6 kg/100 sq. m).**

- d. **3-Inch (75-mm)** Tensile According to ASTM D 882: **400 lbf (1780 N)**, and **11,500 psi (79.2 MPa)**.
  5. Tag: Type ID:
    - a. Detectable three-layer laminate, consisting of a printed pigmented polyolefin film, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
    - b. Overall Thickness: **5 mils (0.125 mm)**.
    - c. Foil Core Thickness: **0.35 mil (0.00889 mm)**.
    - d. Weight: **28 lb/1000 sq. ft. (13.7 kg/100 sq. m)**.
    - e. **3-Inch (75-mm)** Tensile According to ASTM D 882: **70 lbf (311.3 N)**, and **4600 psi (31.7 MPa)**.
  6. Tag: Type IID:
    - a. Reinforced, detectable three-layer laminate, consisting of a printed pigmented woven scrim, a solid aluminum-foil core, and a clear protective film that allows inspection of the continuity of the conductive core, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
    - b. Overall Thickness: **8 mils (0.2 mm)**.
    - c. Foil Core Thickness: **0.35 mil (0.00889 mm)**.
    - d. Weight: **34 lb/1000 sq. ft. (16.6 kg/100 sq. m)**.
    - e. **3-Inch (75-mm)** Tensile According to ASTM D 882: **300 lbf (1334 N)**, and **12,500 psi (86.1 MPa)**.
- G. Warning Labels And Signs
  1. Comply with NFPA 70 and 29 CFR 1910.145.
  2. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.
  3. Baked-Enamel Warning Signs:
    - a. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
    - b. **1/4-inch (6.4-mm)** grommets in corners for mounting.
    - c. Nominal size, **7 by 10 inches (180 by 250 mm)**.
  4. Metal-Backed, Butyrate Warning Signs:
    - a. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with **0.0396-inch (1-mm)** galvanized-steel backing; and with colors, legend, and size required for application.
    - b. **1/4-inch (6.4-mm)** grommets in corners for mounting.
    - c. Nominal size, **10 by 14 inches (250 by 360 mm)**.
  5. Warning label and sign shall include, but are not limited to, the following legends:
    - a. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
    - b. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR **36 INCHES (915 MM)**."
- H. Instruction Signs
  1. Engraved, laminated acrylic or melamine plastic, minimum **1/16 inch (1.6 mm)** thick for signs up to **20 sq. inches (129 sq. cm)** and **1/8 inch (3.2 mm)** thick for larger sizes.
    - a. Engraved legend with black letters on white face.
    - b. Punched or drilled for mechanical fasteners.
    - c. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.
  2. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be **3/8 inch (10 mm)**.
  3. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be **3/8 inch (10 mm)**. Overlay shall provide a weatherproof and UV-resistant seal for label.

I. Equipment Identification Labels

1. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be **3/8 inch (10 mm)**.
2. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be **3/8 inch (10 mm)**. Overlay shall provide a weatherproof and UV-resistant seal for label.
3. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be **3/8 inch (10 mm)**.
4. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be **3/8 inch (10 mm)**.
5. Stenciled Legend: In nonfading, waterproof, black ink or paint. Minimum letter height shall be **1 inch (25 mm)**.

J. Cable Ties

1. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
  - a. Minimum Width: **3/16 inch (5 mm)**.
  - b. Tensile Strength at **73 deg F (23 deg C)**, According to ASTM D 638: **12,000 psi (82.7 MPa)**.
  - c. Temperature Range: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
  - d. Color: Black except where used for color-coding.
2. UV-Stabilized Cable Ties: Fungus inert, designed for continuous exposure to exterior sunlight, self extinguishing, one piece, self locking, Type 6/6 nylon.
  - a. Minimum Width: **3/16 inch (5 mm)**.
  - b. Tensile Strength at **73 deg F (23 deg C)**, According to ASTM D 638: **12,000 psi (82.7 MPa)**.
  - c. Temperature Range: **Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C)**.
  - d. Color: Black.
3. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
  - a. Minimum Width: **3/16 inch (5 mm)**.
  - b. Tensile Strength at **73 deg F (23 deg C)**, According to ASTM D 638: **7000 psi (48.2 MPa)**.
  - c. UL 94 Flame Rating: 94V-0.
  - d. Temperature Range: **Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C)**.
  - e. Color: Black.

K. Miscellaneous Identification Products

1. Paint: Comply with requirements in Division 07 for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).
2. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

1.3 EXECUTION

A. Installation

1. Verify identity of each item before installing identification products.
2. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
3. Apply identification devices to surfaces that require finish after completing finish work.
4. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
5. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
6. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at **50-foot**



(15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.

7. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
8. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
  - a. Outdoors: UV-stabilized nylon.
  - b. In Spaces Handling Environmental Air: Plenum rated.
9. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.
10. Painted Identification: Comply with requirements in Division 07 for surface preparation and paint application.

#### B. Identification Schedule

1. Concealed Raceways, Duct Banks, More Than 600 V, within Buildings: Tape and stencil 4-inch- (100-mm-) wide black stripes on 10-inch (250-mm) centers over orange background that extends full length of raceway or duct and is 12 inches (300 mm) wide. Stencil legend "DANGER CONCEALED HIGH VOLTAGE WIRING" with 3-inch- (75-mm-) high black letters on 20-inch (500-mm) centers. Stop stripes at legends. Apply to the following finished surfaces:
  - a. Floor surface directly above conduits running beneath and within 12 inches (300 mm) of a floor that is in contact with earth or is framed above unexcavated space.
  - b. Wall surfaces directly external to raceways concealed within wall.
  - c. Accessible surfaces of concrete envelope around raceways in vertical shafts, exposed in the building, or concealed above suspended ceilings.
2. Accessible Raceways, Armored and Metal-Clad Cables, More Than 600 V: Self-adhesive vinyl **OR** Snap-around, **as directed**, labels. Install labels at 10-foot (3-m) **OR** 30-foot (10-m), **as directed**, maximum intervals.
3. Accessible Raceways and Metal-Clad Cables, 600 V or Less, for Service, Feeder, and Branch Circuits More Than 30 A, and 120 V to ground: Identify with self-adhesive vinyl label **OR** self-adhesive vinyl tape applied in bands, **as directed**. Install labels at 10-foot (3-m) **OR** 30-foot (10-m), **as directed**, maximum intervals.
4. Accessible Raceways and Cables within Buildings: Identify the covers of each junction and pull box of the following systems with self-adhesive vinyl labels with the wiring system legend and system voltage. System legends shall be as follows:
  - a. Emergency Power.
  - b. Power.
  - c. UPS.
5. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
  - a. Color-Coding for Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.
    - 1) Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
    - 2) Colors for 208/120-V Circuits:
      - a) Phase A: Black.
      - b) Phase B: Red.
      - c) Phase C: Blue.
    - 3) Colors for 480/277-V Circuits:
      - a) Phase A: Brown.
      - b) Phase B: Orange.
      - c) Phase C: Yellow.
    - 4) Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where



- splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
6. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use write-on tags **OR** nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation, **as directed**.
  7. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.
  8. Conductors to Be Extended in the Future: Attach write-on tags **OR** marker tape, **as directed**, to conductors and list source.
  9. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, and signal connections.
    - a. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
    - b. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
    - c. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual.
  10. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.
    - a. Limit use of underground-line warning tape to direct-buried cables.
    - b. Install underground-line warning tape for both direct-buried cables and cables in raceway.
  11. Workspace Indication: Install floor marking tape to show working clearances in the direction of access to live parts. Workspace shall be as required by NFPA 70 and 29 CFR 1926.403 unless otherwise indicated. Do not install at flush-mounted panelboards and similar equipment in finished spaces.
  12. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels **OR** Baked-enamel warning signs **OR** Metal-backed, butyrate warning signs, **as directed**.
    - a. Comply with 29 CFR 1910.145.
    - b. Identify system voltage with black letters on an orange background.
    - c. Apply to exterior of door, cover, or other access.
    - d. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
      - 1) Power transfer switches.
      - 2) Controls with external control power connections.
  13. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
  14. Emergency Operating Instruction Signs: Install instruction signs with white legend on a red background with minimum **3/8-inch- (10-mm-)** high letters for emergency instructions at equipment used for power transfer **OR** load shedding, **as directed**.
  15. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.
    - a. Labeling Instructions:
      - 1) Indoor Equipment: Adhesive film label **OR** Adhesive film label with clear protective overlay **OR** Self-adhesive, engraved, laminated acrylic or melamine label **OR** Engraved, laminated acrylic or melamine label, **as directed**. Unless otherwise indicated, provide a single line of text with **1/2-inch- (13-mm-)** high letters on **1-1/2-inch- (38-mm-)** high label; where two lines of text are required, use labels **2 inches (50 mm)** high.
      - 2) Outdoor Equipment: Engraved, laminated acrylic or melamine label **OR** Stenciled legend **4 inches (100 mm)** high, **as directed**.



- 3) Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.
- 4) Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.
- b. Equipment to Be Labeled:
  - 1) Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved **OR** engraved, **as directed**, laminated acrylic or melamine label.
  - 2) Enclosures and electrical cabinets.
  - 3) Access doors and panels for concealed electrical items.
  - 4) Switchgear.
  - 5) Switchboards.
  - 6) Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
  - 7) Substations.
  - 8) Emergency system boxes and enclosures.
  - 9) Motor-control centers.
  - 10) Enclosed switches.
  - 11) Enclosed circuit breakers.
  - 12) Enclosed controllers.
  - 13) Variable-speed controllers.
  - 14) Push-button stations.
  - 15) Power transfer equipment.
  - 16) Contactors.
  - 17) Remote-controlled switches, dimmer modules, and control devices.
  - 18) Battery-inverter units.
  - 19) Battery racks.
  - 20) Power-generating units.
  - 21) Monitoring and control equipment.
  - 22) UPS equipment.

END OF SECTION 26 05 53 00



## SECTION 26 05 53 00a - INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for intercommunications and program systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes: Manually switched and Microprocessor-switched intercommunications and program systems with the following components:
  - a. Master stations.
  - b. Speaker-microphone stations.
  - c. Call-switch unit.
  - d. All-call amplifier.
  - e. Intercommunication amplifier.
  - f. Paging amplifier.
  - g. Loudspeakers/speaker microphones.
  - h. Conductors and cables.
  - i. Raceways.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For intercommunications and program systems. Include plans, elevations, sections, details, and attachments to other work.
  - a. Wiring Diagrams: For power, signal, and control wiring.
    - 1) Identify terminals to facilitate installation, operation, and maintenance.
    - 2) Single-line diagram showing interconnection of components.
    - 3) Cabling diagram showing cable routing.
3. Field quality-control reports.
4. Operation and maintenance data.

#### D. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with NFPA 70.

### 1.2 PRODUCTS

#### A. Functional Description Of Manually Switched Systems

1. Master Station:
  - a. Communicating selectively with other master and speaker-microphone stations by actuating selector switches.
  - b. Communicating simultaneously with all other stations by actuating a single all-call switch.
  - c. Communicating with individual stations in privacy.
  - d. Including other master-station connections in a multiple-station conference call.
  - e. Accessing separate paging speakers or groups of paging speakers by actuating selector switches.
  - f. Overriding any conversation by a designated master station.



2. Speaker-Microphone Station:
    - a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
    - b. Communicating hands free.
    - c. Calling master station by actuating call switch.
    - d. Returning a busy signal to indicate that station is already in use.
    - e. Being free of noise and distortion during operation and when in standby mode.
  3. Speakers: Free of noise and distortion during operation and when in standby mode.
- B. Functional Description Of Microprocessor-Switched Systems
1. Master Station:
    - a. Communicating selectively with other master and speaker-microphone stations by dialing station's number on a 12-digit keypad.
    - b. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
    - c. Communicating with individual stations in privacy.
    - d. Including other master-station connections in a multiple-station conference call.
    - e. Accessing separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
    - f. Overriding any conversation by a designated master station.
    - g. Displaying selected station.
  2. Speaker-Microphone Station:
    - a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
    - b. Communicating hands free.
    - c. Calling master station by actuating call switch.
    - d. Returning a busy signal to indicate that station is already in use.
    - e. Being free of noise and distortion during operation and when in standby mode.
  3. Speakers: Free of noise and distortion during operation and when in standby mode.
- C. General Requirements For Equipment And Materials
1. Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.
  2. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main trunk cable conductors.
  3. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.
  4. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.
- D. Master Station For Manually Switched Systems
1. Station-Selector and Talk-Listen Switches: Heavy-duty type with gold-plated contacts rated for five million operations.
  2. Volume Control: Regulates incoming-call volume.
  3. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.
  4. Tone Annunciation: Momentary audible tone signal announces incoming calls.
  5. Speaker Microphone: Transmits and receives calls.
  6. Handset with Hook Switch: Telephone type with 18-inch- (450-mm-) long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
  7. Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and auxiliary equipment.

- E. Master Station For Microprocessor-Switched Systems
1. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.
  2. Volume Control: Regulates incoming-call volume.
  3. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.
  4. Tone Annunciation: Momentary audible tone signal announces incoming calls.
  5. Handset with Hook Switch: Telephone type with **18-inch- (450-mm-)** long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
  6. Reset Control: Cancels call and resets system for next call.
  7. Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.
- F. Speaker-Microphone Stations
1. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.
  2. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.
  3. Back Box: Two-gang galvanized steel with **2-1/2-inch (64-mm)** minimum depth.
  4. Speaker: **3 inches (76 mm), 2.3 oz. (65 g)** minimum; permanent magnet.
  5. Tone Annunciation: Recurring momentary tone indicates incoming calls.
  6. Call Switch: Mount on faceplate. Permits calls to master station.
  7. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.
  8. Handset with Hook Switch: Telephone type with **18-inch- (450-mm-)** long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
- G. Call-Switch Unit
1. Enclosure: Single-gang box with stainless-steel faceplate.
  2. Call Switch: Momentary contact signals system that a call has been placed.
  3. Privacy Switch: Prevents transmission of sound signals from station to system.
  4. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.
  5. Handset with Hook Switch: Telephone type with **18-inch- (450-mm-)** long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
- H. All-Call Amplifier
1. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.
  2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.
  3. Minimum Signal-to-Noise Ratio: 45 dB, at rated output.
  4. Frequency Response: Within plus or minus 3 dB from 70 to 12,000 Hz.
  5. Output Regulation: Maintains output level within 2 dB from full to no load.
  6. Input Sensitivity: Compatible with master stations and central equipment so amplifier delivers full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on master stations, speaker microphones, or handset transmitters.
  7. Amplifier Protection: Prevents damage from shorted or open output.
- I. Intercommunication Amplifier
1. Minimum Output Power: 2 W; adequate for all functions.
  2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.
  3. Minimum Signal-to-Noise Ratio: 45 dB, at rated output.
  4. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.



5. Output Regulation: Maintains output level within 2 dB from full to no load.
  6. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on master stations, speaker microphones, or handset transmitters.
  7. Amplifier Protection: Prevents damage from shorted or open output.
- J. Paging Amplifier
1. Input Voltage: 120-V ac, 60 Hz.
  2. Frequency Response: Within plus or minus 3 dB from 60 to 10,000 Hz.
  3. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
  4. Total Harmonic Distortion: Less than 3 percent at rated power output from 70 to 12,000 Hz.
  5. Output Regulation: Less than 2 dB from full to no load.
  6. Controls: On-off, input levels, and low-cut filter.
  7. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphones or handset transmitters.
  8. Amplifier Protection: Prevents damage from shorted or open output.
  9. Output Circuit: 70-V line.
- K. Cone-Type Loudspeakers/Speaker Microphones
1. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
  2. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.
  3. Minimum Dispersion Angle: 100 degrees.
  4. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.
  5. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least **0.0478-inch (1.2-mm)** steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.
  6. Baffle: For flush speakers, minimum thickness of **0.032-inch (0.8-mm)** aluminum brushed to a satin sheen and lacquered **OR** with textured white finish, **as directed**.
  7. Vandal-Proof, High-Strength Baffle: For flush **OR** surface, **as directed**, -mounted speakers, self-aging cast aluminum with tensile strength of **44,000 psi (303 MN/sq. m)**, **0.025-inch (0.65-mm)** minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.
  8. Size: **8 inches (200 mm)** with **1-inch (25-mm)** voice coil and minimum **5-oz. (140-g)** ceramic magnet.
- L. Horn-Type Loudspeakers/Speaker Microphones
1. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.
  2. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.
  3. Minimum Power Rating of Driver: 15 W, continuous.
  4. Minimum Dispersion Angle: 110 degrees.
  5. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.
- M. Horn-Type Explosion-Proof Loudspeakers
1. Speakers shall be all-metal construction; complete with universal mounting brackets.
  2. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located.
  3. Frequency Response: Within plus or minus 3 dB from 300 to 12,000 Hz.
  4. Minimum Power Rating of Driver: 30 **OR** 60, **as directed**, W, continuous.
  5. Minimum Dispersion Angle: 95 **OR** 60 by 120, **as directed**, degrees.
  6. Line Transformer: Internally mounted and factory installed, power rating equal to speaker's, and at least four level taps.

N. Conductors And Cables

1. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
2. Insulation: Thermoplastic, not less than **1/32 inch (0.8 mm)** thick.
3. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
  - a. Minimum Shielding Coverage on Conductors: 60 percent.
4. Plenum Cable: Listed and labeled for plenum installation.

O. Raceways

1. Intercommunication and Program System Raceways and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems".
2. Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
3. Intercommunication and Program System Raceways and Boxes: EMT **OR** ENT **OR** RNC **OR** Optical-fiber/communication raceways and fittings **OR** Metal wireways **OR** Nonmetal wireways **OR** Surface metal raceways **OR** Surface nonmetal raceways, **as directed**.
4. Outlet boxes shall be not less than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
5. Flexible metal conduit is prohibited.

1.3 EXECUTION

A. Wiring Methods

1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
  - a. Install plenum cable in environmental air spaces, including plenum ceilings.
  - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

B. Installation Of Raceways

1. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
2. Install manufactured conduit sweeps and long-radius elbows whenever possible.

C. Installation Of Cables

1. Comply with NECA 1.
2. General Requirements:
  - a. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
  - b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
  - c. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
  - d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

- e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
  - f. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.
  - 3. Open-Cable Installation:
    - a. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
    - b. Suspend speaker cable not in a wireway or pathway a minimum of **8 inches (200 mm)** above ceiling by cable supports not more than **60 inches (1524 mm)** apart.
    - c. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
  - 4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least **12 inches (300 mm)** apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.
- D. Installation
- 1. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
  - 2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
  - 3. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
  - 4. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.
  - 5. Connect wiring according to Division 26 Section "Grounding And Bonding For Electrical Systems".
- E. Grounding
- 1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
  - 2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
  - 3. Install grounding electrodes as specified in Division 26 Section "Grounding And Bonding For Electrical Systems".
- F. System Programming
- 1. Programming: Fully brief the Owner on available programming options. Record the Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.
- G. Field Quality Control
- 1. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  - 2. Tests and Inspections:
    - a. Schedule tests with at least seven days' advance notice of test performance.
    - b. After installing intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.
    - c. Operational Test: Test originating station-to-station, all-call, and page messages at each intercommunication station. Verify proper routing and volume levels and that system is



- free of noise and distortion. Test each available message path from each station on system.
- d. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging, by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
  - e. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
    - 1) Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at speakers or paging speakers.
    - 2) Repeat test for four speaker microphones and for each separately controlled zone of paging loudspeakers.
    - 3) Minimum acceptable ratio is 35 dB.
  - f. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each paging and all-call amplifier, and a minimum of two selected intercommunication amplifiers. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.
  - g. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at three locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.
  - h. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.
  - i. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".
- 3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
  - 4. Intercommunications and program systems will be considered defective if they do not pass tests and inspections.
  - 5. Prepare test and inspection reports.

END OF SECTION 26 05 53 00a



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Task	Specification	Specification Description
26 05 83 00	26 05 13 16	Conductors And Cables
26 05 83 00	26 05 13 16a	Undercarpet Cables
26 05 83 00	26 05 13 16b	Medium-Voltage Cables

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## SECTION 26 09 23 00 - LIGHTING CONTROLS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for lighting controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes manually operated lighting controls with relays, electrically operated circuit breakers, and control module.
2. This Section includes manually operated, PC-based, digital lighting controls with external signal source, relays, electrically operated circuit breakers, and control module.
3. This Section includes individually addressable lighting control devices communicating with data-entry and -retrieval devices using DALI protocol.

#### C. Definitions

1. BACnet: A networking communication protocol that complies with ASHRAE 135.
2. BAS: Building automation system.
3. DALI: Digital addressable lighting interface.
4. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
5. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
6. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
7. PC: Personal computer; sometimes plural as "PCs."
8. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.
9. RS-485: A serial network protocol, similar to RS-232, complying with TIA/EIA-485-A.

#### D. Submittals

1. Product Data: For control modules, power distribution components, DALI network materials, manual switches and plates, and conductors and cables.
2. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on this Project.
  - a. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
  - b. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
  - c. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
3. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
  - a. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
  - b. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.

4. Software and Firmware Operational Documentation:
    - a. Software operating and upgrade manuals.
    - b. Program Software Backup: On a magnetic media or compact disc, complete with data files.
    - c. Device address list.
    - d. Printout of software application and graphic screens.
  5. Field quality-control test reports.
  6. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
  7. Operation and maintenance data.
  8. Warranty: Special warranty specified in this Section.
- E. Quality Assurance
1. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.
  2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
  3. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
  4. Comply with protocol described in IEC 60929, Annex E, for DALI lighting control devices, wiring, and computer hardware and software.
  5. Comply with NFPA 70.
- F. Coordination
1. Coordinate lighting control components to form an integrated interconnection of compatible components. Match components and interconnections for optimum performance of lighting control functions.
    - a. Coordinate lighting controls with BAS **OR** HVAC controls, **as directed**. Design display graphics showing building areas controlled; include the status of lighting controls in each area.
    - b. Coordinate lighting controls with that in Sections specifying distribution components that are monitored or controlled by power monitoring and control equipment.
  2. Coordinate lighting control components specified in this Section with components specified in Division 26 Section "Panelboards".
- G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
    - a. Failures include, but are not limited to, the following:
      - 1) Failure of software input/output to execute switching or dimming commands.
      - 2) Failure of modular relays to operate under manual or software commands.
      - 3) Damage of electronic components due to transient voltage surges.
    - b. Warranty Period: Two years from date of Final Completion.
    - c. Extended Warranty Period Failure Due to Transient Voltage Surges: Eight years.
    - d. Extended Warranty Period for Electrically Held Relays: 10 years from date of Final Completion.
- H. Software Service Agreement (May Not Be Allowed For Publicly Funded Projects)
1. Technical Support: Beginning with Final Completion, provide software support for two years.
  2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revise licenses for use of the software.

- a. Provide 30-day notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment, if necessary.

## 1.2 PRODUCTS

### A. System Requirements

1. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.
2. Performance Requirements (for programmable system that controls manual and automatic operation that is not PC based): Manual switch operation sends a signal to programmable-system control module that processes the signal according to its programming and routes an open or close command to one or more relays **OR** electrically operated circuit breakers, **as directed**, in the power-supply circuits to groups of lighting fixtures or other loads.
3. Performance Requirements (for PC-based programmable system that controls manual and automatic operation): Manual switches, an internal timing and control unit, and external sensors or other control signal sources send a signal to a PC-based programmable-system control module that processes the signal according to its programming and routes an open or close command to one or more relays **OR** electrically operated circuit breakers, **as directed**, in the power-supply circuits, or routes variable commands to one or more dimmers, for groups of lighting fixtures or other loads.
4. Performance Requirements (for DALI-compliant program): Individually addressable devices (such as electronic ballasts, dimmers, and manual switches) are operated from digital signals received through a DALI-compliant bus, from data-entry and -retrieval devices (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs). Devices also report status to data-entry and -retrieval devices through the bus.
5. BAS Interface: Provide hardware and software to enable the BAS to monitor, control, display, and record data for use in processing reports.
  - a. Hardwired Points:
    - 1) Monitoring: On-off status, **<Insert monitoring point>**.
    - 2) Control: On-off operation, **<Insert control point>**.
  - b. ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely control and monitor lighting from a BAS operator workstation. Control features and monitoring points displayed locally at lighting panel shall be available through the BAS.

### B. Control Module

1. Control Module Description: (This is a generic, nonproprietary control module that is not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral alphanumeric LCD or LED shall display menu-assisted programming and control.
2. Control Module Description: (These are typical systems developed by time-switch manufacturers as an expansion and refinement of their microprocessor-based, digital, time-switch product lines - controls are not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Unit shall be programmable for control of indicated number of output circuits. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices, all located in other enclosures. An integral keypad shall provide local programming and control capability. A key-locked cover and a programmed security access code shall protect keypad use. An integral



alphanumeric LCD shall display manual-control and programming steps. Modules and their associated control panels shall include the following features:

- a. Multichannel output with **<Insert number>** channels.  
**OR**  
 Multiple inputs and multichannel output arranged for **<Insert number>** channels.
- b. Multiple inputs for indicated occupancy sensors and hand-held programming device.
3. Control Module Description: (These are low-voltage control systems developed by high-end, remote-control dimmer system manufacturers - controls are not PC based.) Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Control units shall be programmable and capable of receiving inputs from indicated sensors and hand-held programmer. Output circuits shall be pilot-duty relays compatible with power switching devices. Output circuits shall include digital circuits arranged to transmit control commands to remote preset dimmers. Modules and their associated control panels shall include the following features:
  - a. Multichannel output with **<Insert number>** channels.  
**OR**  
 Multiple inputs and multichannel output arranged for **<Insert number>** channels.
  - b. Multiple inputs for occupancy sensors, daylight sensors, and dimming systems with associated daylight sensors.
4. Control Module Description: (This is a low-voltage control system developed around panelboards with electrically operated, molded-case circuit breakers and control module installed in panelboard - controls are not PC based.) Panelboard mounted; comply with UL 916 (CSA C22.2, No. 205); microprocessor based, solid-state, 365-day timing and control unit. Control units shall be programmable and capable of receiving inputs from sensors and other sources. Panelboard shall use low-voltage-controlled, electrically operated, molded-case branch circuit breakers as prime power-circuit switching devices. Circuit breakers and a limited number of digital or analog, low-voltage control-circuit outputs shall be individually controlled by control module. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable. Panelboard shall also comply with Division 26 Section "Panelboards".
5. Control Module Description: (This is a refinement of classic low-voltage control system originally developed for manual, multipoint lighting control using latching-type, single-pole relays to switch 120- and 277-V circuits - controls are not PC based.) Comply with UL 508 (CSA C22.2, No. 14); microprocessor-based, programmable, control unit; mounted in preassembled, modular relay panel. Low-voltage-controlled, latching-type, single-pole lighting circuit relays shall be prime output circuit devices. Where indicated, a limited number of digital or analog, low-voltage control-circuit outputs shall be supported by control unit and circuit boards associated with relays. Control units shall be capable of receiving inputs from sensors and other sources. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable.
6. Control Module Description: (This is a typical PC-based software control system developed to operate panelboards with electrically operated circuit breakers, relay boards with latching-type control relays, and individually addressable DALI-compliant devices. This control scheme is also suitable for integrating one or more of these boards to a PC-based control network (such as BAS, detention monitoring and control system, and HVAC control system) specified in another Section.) Programmable, PC-based unit with 17-inch color video monitor **OR** 15-inch color LCD, **as directed**, and keyboard for graphic display and programming of system status and to override breaker status; and to display status of local override controls and diagnostic information. If the control module is applied to emergency lighting units, control unit shall indicate failure of normal power and that the lighting units are, or are not, powered by the alternate power source.
  - a. Display: Single graphic display for programming lighting control panelboards.  
**OR**  
 Display: Separate graphic displays for programming each lighting control panelboard.
  - b. Interoperability: Control module shall be configured to connect with other control systems using RS-485 network to enable remote workstations to use control module functions.



**OR**

Interoperability: Control module shall be configured to connect to LonWorks-compliant **OR** BACnet-compliant, **as directed**, network, resulting in extending control to any network-compliant devices such as occupancy switches.

**OR**

Interoperability: Lighting control shall be configured to allow individual users to turn lighting on and off with their PCs. Software shall be written for Windows operating system, with Web page as the display and ActiveX controls that can be accessed through an Internet browser. Include at least three levels of password protection. Include an egress lighting option that will provide each user with a lighted path for exiting the building after normal working hours.

**OR**

Interoperability: Lighting control shall be configured to allow individual users to turn lighting on and off with DALI-compliant, digital-communication devices. Software shall be written for Windows operating system, with the full suite of DALI commands and device parameter settings.

- c. System Memory: Nonvolatile. System shall reboot program and reset time automatically without errors after power outages up to 90 days' duration.
  - d. Software: Lighting control software shall be capable of linking switch inputs to relay outputs, retrieving links, viewing relay output status, controlling relay outputs, simulating switch inputs, setting device addresses, and assigning switch input and relay output modes.
  - e. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight saving time and shall provide weekly routine and annual holiday scheduling.
  - f. Astronomic Control: Automatic adjustment of dawn and dusk switching.
  - g. Demand Control: Demand shall be monitored through pulses from a remote meter and shall be controlled by programmed switching of loads. System capability shall include sliding window averaging and programming of load priorities and characteristics. Minimum of two different time-of-day demand schedules shall execute load-management control actions by switching output circuits or by transmitting other types of load-control signals.
  - h. Confirmation: Each relay or contactor device operated by system shall have auxiliary contacts that provide a confirmation signal to the system of on or off status of device. On or off status confirmation for each electrically operated circuit breaker shall be provided by an auxiliary contact or by a sensing device at load terminal.
    - 1) Software shall interpret status signals, provide for their display, and initiate failure signals.
- OR**
- Lamp or LED at control module or display panel shall identify status of each controlled circuit.
- i. Remote Communication Capability: Allow programming, data-gathering interrogation, status display, and controlled command override from a PC at a remote location over telephone lines **OR** data links **OR** DALI networks **OR** power line carrier, **as directed**. System shall include modem, communications and control software, and remote computer compatibility verification for this purpose.
  - j. Telephone Override Capability: Override programmed lighting shutdown commands by telephoning computer and shall enter a voice-menu-guided, override touch-tone code specific to zone being controlled.
  - k. Local Override Capability: Manual, low-voltage control devices shall override programmed shutdown of lighting and shall override other programmed control for intervals that may be duration programmed.
  - l. Automatic Control of Local Override: Automatic control shall switch lighting off if lighting has been switched on by local override. Comply with provisions in California Code of Regulations, Title 24, Part 6, **as directed**.
  - m. Automatic battery backup shall provide power to maintain program and system clock operation for 90 days' minimum duration when power is off.
  - n. Programmed time signals shall change preset scenes and dimmer settings.



- o. Daylight Balancing Dimming Control: Control module shall interpret variable analog signal from photoelectric sensor and shall route dimming signals to dimming fluorescent ballast control circuits. Signal shall control dimming of fixture so illumination level remains constant as daylight contribution varies.
- p. Daylight Compensating Switch Control: Control module shall interpret a preset threshold illumination-level signal from a photoelectric relay and shall activate relays controlling power to selected groups of lighting fixtures to turn them on and off to maintain adjustable minimum illumination level as daylight contribution varies.
- q. Energy Conservation: Bilevel control of special ballasts or dimming circuits to comply with local energy codes.
- r. Flick Warning: Programmable momentary turnoff of lights shall warn that programmed shutoff will occur after a preset interval. Warning shall be repeated after a second preset interval before end of programmed override period.
- s. Diagnostics: When system operates improperly, software shall initiate factory-programmed diagnosis of failure and display messages identifying problem and possible causes.
- t. Additional Programming: In addition to system programming by the PC, individual control modules shall be programmable using data-entry and -retrieval (such as PCs, personal digital assistants (PDAs), hand-held infrared programming devices, wired Ethernet hubs, wireless IEEE 802.11 hubs).

C. Power Distribution Components (For DALI-Compliant Networks)

1. Modular Relay Panel: Comply with UL 508 (CSA C22.2, No. 14) and UL 916 (CSA C22.2, No. 205); factory assembled with modular single-pole relays, power supplies, and accessory components required for specified performance.
  - a. Cabinet: Steel with hinged, locking door.
    - 1) Barriers separate low-voltage and line-voltage components.
    - 2) Directory: Mounted on back of door. Identifies each relay as to load groups controlled and each programmed pilot device if any.
    - 3) Control Power Supply: Transformer and full-wave rectifier with filtered dc output.
  - b. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type.
    - 1) Low-Voltage Leads: Plug connector to the connector strip in cabinet and pilot light power where indicated.
    - 2) Rated Capacity (Mounted in Relay Panel): 20 A, 125-V ac for tungsten filaments; 20 A, 277-V ac for ballasts.
    - 3) Endurance: 50,000 cycles at rated capacity.
    - 4) Mounting: Provision for easy removal and installation in relay cabinet.
2. Electrically Operated, Molded-Case Circuit-Breaker Panelboard: Comply with NEMA PB 1 and UL 50 (CSA C22.2, No. 94), UL 67 (CSA C22.2, No. 29), UL 489 (CSA C22.2, No. 65), and UL 916 (CSA C22.2, No. 205).
  - a. Cabinets: In addition to requirements specified below, comply with Division 26 Section "Panelboards".
  - b. Electrically Operated, Molded-Case Circuit Breakers: Bolt-on type.
    - 1) Switching Endurance Ratings: Certified by manufacturer or by a nationally recognized testing laboratory (NRTL) for at least 20,000 open and close operations under rated load at 0.8 power factor.
    - 2) Minimum 30,000 open and close operations with load equal to circuit-breaker trip rating and consisting of 100 percent tungsten filament load.
    - 3) Minimum 30,000 open and close operations with load equal to circuit-breaker trip rating and consisting of 100 percent fluorescent ballasts rated for 10 percent total harmonic distortion.
    - 4) Listed and labeled as complying with UL SWD, HCAR, and HID ratings by a national recognized testing laboratory (NRTL) acceptable to authorities having jurisdiction.
3. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels.

**OR**

Line-Voltage Surge Suppression: Field-mounting surge suppressors that comply with Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" for Category A locations.

**OR**

Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels or field-mounting surge suppressors that comply with Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" for Category A locations.

D. DALI Network Materials

1. Network Power Supply and Router: Interface device connecting TCP/IP control networks to DALI-compliant network.
  - a. DALI-Compliant Network Power Rating: One full-rated network for **OR** Two full-rated networks, each capable of, **as directed**, powering up to 64 addressable devices for each network; suitable for use with NFPA 70, Class 1 and Class 2 control circuits; and 16 V dc, 250 mA.
  - b. Primary Power: 120 or 277 V, field selectable; 12 VA.
  - c. 10basT Ethernet port.
  - d. LED indicator lights for Ethernet status (link, send, and receive), power-on, and DALI network failure.
2. Lighting Control Software:
  - a. Five-tier hierarchical architecture; high-speed, parallel query; and distributed-logic processing scalable from single rooms to full campuses.
  - b. Automatic backup for all settings and parameters.
  - c. TCP/IP network protocol.
  - d. Interactive with other building management systems at TCP/IP level.
  - e. At least three security levels.
  - f. Support the full suite of DALI commands and device parameter settings.
  - g. Scheduling modules to provide building-wide scene scheduling.
  - h. Billing modules to track energy use for multiple tenants and able to produce monthly billing statements.
  - i. Support load shedding, peak shaving, sweeps with local override, and other energy-conservation measures.
  - j. Able to report individual device status, including inoperative lamps, ballast failure detection, and dimmer position.

E. Manual Switches And Plates

1. Push-Button Switches: Modular, momentary-contact, low-voltage type.
  - a. Match color specified in Division 26 Section "Wiring Devices".
  - b. Integral green LED **OR** neon, **as directed**, pilot light to indicate when circuit is on.
  - c. Internal white LED **OR** neon, **as directed**, locator light to illuminate when circuit is off.
2. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Division 26 Section "Wiring Devices".
3. Wall-Box Dimmers: Comply with Division 26 Section "Wiring Devices".
4. Wall Plates: Single and multigang plates as specified in Division 26 Section "Wiring Devices"
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

F. Conductors And Cables

1. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
2. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG, complying with Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

3. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 14 **OR** 16 **OR** 18, **as directed**, AWG, complying with Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
4. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e **OR** 6, **as directed**, for horizontal copper cable and with Division 28 Section "Conductors And Cables For Electronic Safety And Security".

### 1.3 EXECUTION

#### A. Wiring Installation

1. Comply with NECA 1.
2. Wiring Method: Install wiring in raceways except where installed in accessible ceilings and gypsum board partitions. Comply with Division 26 Section "Low-voltage Electrical Power Conductors And Cables". Minimum conduit size shall be **1/2 inch (13 mm)**.
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
4. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
5. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
6. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.
7. Identify components and power and control wiring according to Division 26 Section "Identification For Electrical Systems".

#### B. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
  - a. Test for circuit continuity.
  - b. Verify that the control module features are operational.
  - c. Check operation of local override controls.
  - d. Test system diagnostics by simulating improper operation of several components selected by the Owner.

#### C. Software Installation

1. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

#### D. Adjusting

1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting sensors and to assist the Owner's personnel in making program changes to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose.

#### E. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain lighting controls and software training for PC-based control systems.

END OF SECTION 26 09 23 00

## SECTION 26 09 23 00a - LIGHTING CONTROL DEVICES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for lighting control devices. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following lighting control devices:
  - a. Time switches.
  - b. Outdoor and Indoor photoelectric switches.
  - c. Indoor occupancy sensors.
  - d. Outdoor motion sensors.
  - e. Lighting contactors.
  - f. Emergency shunt relays.

#### C. Definitions

1. LED: Light-emitting diode.
2. PIR: Passive infrared.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Field quality-control test reports.
3. Operation and maintenance data.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

### 1.2 PRODUCTS

#### A. Time Switches

1. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
  - a. Contact Configuration: SPST **OR** DPST **OR** DPDT, **as directed**.
  - b. Contact Rating: 30-A inductive or resistive, 240-V ac **OR** 20-A ballast load, 120/240-V ac, **as directed**.
  - c. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.  
**OR**  
Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.  
**OR**  
Programs: channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.  
**OR**  
Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule with skip-a-day weekly schedule.



**OR**

Programs: channels; each channel shall be individually programmable with 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week.

**OR**

Programs: channels; each channel shall be individually programmable with 40 on-off operations per week and an annual holiday schedule that overrides the weekly operation on holidays.

**OR**

Programs: channels; each channel shall be individually programmable with 40 on-off operations per week, plus 4 seasonal schedules that modify the basic program, and an annual holiday schedule that overrides the weekly operation on holidays.

**OR**

Program: Configuration, as directed by the Owner and an annual holiday schedule that overrides the weekly operation on holidays, **as directed**.

- d. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels, **as directed**.
- e. Astronomic Time: All **OR** Selected, **as directed**, channels.
- f. Battery Backup: For schedules and time clock.
2. Electromechanical-Dial Time Switches: Type complying with UL 917.
  - a. Contact Configuration: SPST **OR** DPST **OR** SPDT **OR** DPDT, **as directed**.
  - b. Contact Rating: 30-A inductive or resistive, 240-V ac **OR** 20-A ballast load, 120/240-V ac, **as directed**.
  - c. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
  - d. Astronomic time dial.
  - e. Eight-Day Program: Uniquely programmable for each weekday and holidays.
  - f. Skip-a-day mode.
  - g. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

#### B. Outdoor Photoelectric Switches

1. Description: Solid state, with SPST **OR** DPST, **as directed**, dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
  - a. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off, **as directed**.
  - b. Time Delay: 15-second minimum, to prevent false operation.
  - c. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
  - d. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

**OR**

Description: Solid state, with SPST **OR** DPST, **as directed**, dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

- a. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
- b. Time Delay: 30-second minimum, to prevent false operation.
- c. Lightning Arrester: Air-gap type.
- d. Mounting: Twist lock complying with IEEE C136.10, with base.

#### C. Indoor Photoelectric Switches

1. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit mounted on luminaire, **as directed**, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
    - a. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
    - b. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
    - c. Light-Level Monitoring Range: **10 to 200 fc (108 to 2152 lx) OR 100 to 1000 fc (1080 to 10 800 lx)**, **as directed**, with an adjustment for turn-on and turn-off levels within that range.
    - d. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
    - e. Indicator: Two LEDs to indicate the beginning of on-off cycles.
  2. Skylight Photoelectric Sensors: Solid-state, light-level sensor; housed in a threaded, plastic fitting for mounting under skylight, facing up at skylight; with separate relay unit mounted on luminaire, **as directed**, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photoresistors are not acceptable.
    - a. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
    - b. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
    - c. Light-Level Monitoring Range: **1000 to 10,000 fc (10 800 to 108 000 lx)**, with an adjustment for turn-on and turn-off levels within that range.
    - d. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
    - e. Indicator: Two LEDs to indicate the beginning of on-off cycles.
- D. Indoor Occupancy Sensors
1. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
    - a. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    - b. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
    - c. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
    - d. Mounting:
      - 1) Sensor: Suitable for mounting in any position on a standard outlet box.
      - 2) Relay: Externally mounted through a **1/2-inch (13-mm)** knockout in a standard electrical enclosure.
      - 3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
    - e. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
    - f. Bypass Switch: Override the on function in case of sensor failure.
    - g. Automatic Light-Level Sensor: Adjustable from **2 to 200 fc (21.5 to 2152 lx)**; keep lighting off when selected lighting level is present.
  2. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
    - a. Detector Sensitivity: Detect occurrences of **6-inch- (150-mm-)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. in. (232 sq. cm)**.
    - b. Detection Coverage (Room): Detect occupancy anywhere in a circular area of **1000 sq. ft. (93 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.



- c. Detection Coverage (Corridor): Detect occupancy within **90 feet (27.4 m)** when mounted on a **10-foot- (3-m-)** high ceiling.
  - 3. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
    - a. Detector Sensitivity: Detect a person of average size and weight moving not less than **12 inches (305 mm)** in either a horizontal or a vertical manner at an approximate speed of **12 inches/s (305 mm/s)**.
    - b. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of **600 sq. ft. (56 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.
    - c. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of **1000 sq. ft. (93 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.
    - d. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of **2000 sq. ft. (186 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.
    - e. Detection Coverage (Corridor): Detect occupancy anywhere within **90 feet (27.4 m)** when mounted on a **10-foot- (3-m-)** high ceiling in a corridor not wider than **14 feet (4.3 m)**.
  - 4. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
    - a. Sensitivity Adjustment: Separate for each sensing technology.
    - b. Detector Sensitivity: Detect occurrences of **6-inch- (150-mm-)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. in. (232 sq. cm)**, and detect a person of average size and weight moving not less than **12 inches (305 mm)** in either a horizontal or a vertical manner at an approximate speed of **12 inches/s (305 mm/s)**.
    - c. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of **1000 sq. ft. (93 sq. m)** when mounted on a **96-inch- (2440-mm-)** high ceiling.
- E. Outdoor Motion Sensors (PIR)
  - 1. Performance Requirements: Suitable for operation in ambient temperatures ranging from **minus 40 to plus 130 deg F (minus 40 to plus 54 deg C)**, rated as raintight according to UL 773A.
    - a. Operation: Turn lights on when sensing infrared energy changes between background and moving body in area of coverage; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
    - b. Mounting:
      - 1) Sensor: Suitable for mounting in any position on a standard outdoor junction box.
      - 2) Relay: Internally mounted in a standard weatherproof electrical enclosure.
      - 3) Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
    - c. Bypass Switch: Override the on function in case of sensor failure.
    - d. Automatic Light-Level Sensor: Adjustable from **1 to 20 fc (11 to 215 lx)**; keep lighting off during daylight hours.
  - 2. Detector Sensitivity: Detect occurrences of **6-inch- (150-mm-)** minimum movement of any portion of a human body that presents a target of not less than **36 sq. in. (232 sq. cm)**.
  - 3. Detection Coverage: Up to **35 feet (11 m)**, with a field of view of 90 degrees **OR** Up to **100 feet (30 m)**, with a field of view of 60 degrees **OR** Up to **35 feet (11 m)**, with a field of view of 180 degrees **OR** Up to **52.5 feet (16 m)**, with a field of view of 270 degrees, **as directed**.
  - 4. Lighting Fixture Mounted Sensor: Suitable for switching 300 W of tungsten load at 120- or 277-V ac.
  - 5. Individually Mounted Sensor: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
    - a. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.

- b. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.

F. Lighting Contactors

- 1. Description: Electrically operated and mechanically **OR** electrically, **as directed**, held, combination type with fusible switch **OR** nonfused disconnect, **as directed**, complying with NEMA ICS 2 and UL 508.
  - a. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
  - b. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
  - c. Enclosure: Comply with NEMA 250.
  - d. Provide with control and pilot devices as indicated on Drawings **OR** scheduled, **as directed**, matching the NEMA type specified for the enclosure.
- 2. BAS Interface: Provide hardware interface to enable the BAS to monitor and control lighting contactors.
  - a. Monitoring: On-off status, as directed by the Owner.
  - b. Control: On-off operation, as directed by the Owner.

G. Emergency Shunt Relay

- 1. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual or automatic, **as directed**, switching contacts; complying with UL 924.
  - a. Coil Rating: 120 **OR** 277, **as directed**, V.

H. Conductors And Cables

- 1. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- 2. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR** 22 **OR** 24, **as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- 3. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 **OR** 16 **OR** 18, **as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

### 1.3 EXECUTION

A. Sensor Installation

- 1. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

B. Contactor Installation

- 1. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

C. Wiring Installation

- 1. Wiring Method: Comply with Division 26 Section "Low-voltage Electrical Power Conductors And Cables". Minimum conduit size shall be **1/2 inch (13 mm)**.
- 2. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
- 3. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.



4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

D. Identification

1. Identify components and power and control wiring according to Division 26 Section "Identification For Electrical Systems".
  - a. Identify controlled circuits in lighting contactors.
  - b. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.
2. Label time switches and contactors with a unique designation.

E. Field Quality Control

1. Perform the following field tests and inspections and prepare test reports:
  - a. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
  - b. Operational Test: Verify operation of each lighting control device, and adjust time delays.
2. Lighting control devices that fail tests and inspections are defective work.

END OF SECTION 26 09 23 00a

## SECTION 26 09 23 00b - ELECTRICAL POWER MONITORING AND CONTROL

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for electrical power monitoring and control. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following for monitoring and control of electrical power system:
  - a. PC-based workstation(s) and software.
  - b. Communication network and interface modules for RS-232; RS-485, Modbus TCP/IP; and IEEE 802.3 data transmission protocols.

#### C. Definitions

1. Ethernet: Local area network based on IEEE 802.3 standards.
2. Firmware: Software (programs or data) that has been written onto read-only memory (ROM). Firmware is a combination of software and hardware. Storage media with ROMs that have data or programs recorded on them are firmware.
3. HTML: Hypertext markup language.
4. I/O: Input/output.
5. KB: Short for kilobyte. When used to describe data storage, "KB" represents 1024 bytes.
6. KY Pulse: A term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay changing status in response to the rotation of the disk in the meter.
7. LAN: Local area network; sometimes plural as "LANs."
8. LCD: Liquid crystal display.
9. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or remote-control, signaling and power-limited circuits.
10. Modbus TCP/IP: An open protocol for exchange of process data.
11. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
12. PC: Personal computer; sometimes plural as "PCs."
13. rms: Root-mean-square value of alternating voltage, which is the square root of the mean value of the square of the voltage values during a complete cycle.
14. RS-232: A TIA standard for asynchronous serial data communications between terminal devices.
15. RS-485: A TIA standard for multipoint communications using two twisted-pairs.
16. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
17. THD: Total harmonic distortion.
18. UPS: Uninterruptible power supply; used both in singular and plural context.
19. WAN: Wide area network.

#### D. Submittals

1. Product Data: For each type of product indicated.
  - a. Attach copies of approved Product Data submittals for products (such as switchboards and switchgear) that describe power monitoring and control features to illustrate coordination among related equipment and power monitoring and control.
2. Shop Drawings: For power monitoring and control equipment. Include plans, elevations, sections, details, and attachments to other work.
  - a. Outline Drawings: Indicate arrangement of components and clearance and access requirements.



- b. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
    - c. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
    - d. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
    - e. UPS sizing calculations for workstation.
  3. Software and Firmware Operational Documentation:
    - a. Self-study guide describing the process for setting equipment's network address; setting the Owner's options; procedures to ensure data access from any PC on the network, using a standard Web browser; and recommended firewall setup.
    - b. Software operating and upgrade manuals.
    - c. Software Backup: On a magnetic media or compact disc, complete with the Owner-selected options.
    - d. Device address list and the set point of each device and operator option, as set in applications software.
    - e. Graphic file and printout of graphic screens and related icons, with legend.
  4. Software Upgrade Kit: For the Owner to use in modifying software to suit future power system revisions or power monitoring and control revisions.
  5. Software licenses and upgrades required by and installed for operating and programming digital and analog devices.
  6. Field quality-control test reports.
  7. Operation and Maintenance Data: For power monitoring and control units, to include in emergency, operation, and maintenance manuals. Include the following:
    - a. Operating and applications software documentation.
    - b. Software licenses.
    - c. Software service agreement.
    - d. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
    - e. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
  8. Other Informational Submittals:
    - a. System installation and setup guides, with data forms to plan and record options and setup decisions.
- E. Quality Assurance
  1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- F. Software Service Agreement
  1. Technical Support: Beginning with Final Completion, provide software support for two years.
  2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include the operating systems. Upgrade shall include new or revised licenses for use of software.
    - a. Provide 30-day notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

## 1.2 PRODUCTS

### A. Functional Description

1. Instrumentation and Recording Devices: Monitor and record load profiles and chart energy consumption patterns.
  - a. Calculate and Record the Following:
    - 1) Load factor.
    - 2) Peak demand periods.
    - 3) Consumption correlated with facility activities.
  - b. Measure and Record Metering Data for the Following:
    - 1) Electricity.
    - 2) Domestic water.
    - 3) Natural gas.
2. Software: Calculate allocation of utility costs.
  - a. Automatically Import Energy Usage Records to Allocate Energy Costs for the Following:
    - 1) At least 15 departments.
    - 2) At least 30 tenants.
    - 3) At least five processes.
    - 4) At least five buildings.
  - b. Verify utility bills and analyze alternate energy rates, **as directed**.
3. Power Quality Monitoring: Identify power system anomalies and measure, display, and record trends and alarms of the following power quality parameters:
  - a. Voltage regulation and unbalance.
  - b. Continuous three-phase rms voltage.
  - c. Periodic max./min./avg. samples.
  - d. Harmonics.
  - e. Voltage excursions.
4. Emergency Load Shedding. Preserve critical loads or avoid total shutdown due to unforeseen loss of power sources according to the following logic:
  - a. Determine system topology.
  - b. Evaluate remaining loads and sources.
  - c. Shed loads in less than 100 ms.
5. Demand Management:
  - a. Peaking or co-generator control.
  - b. Load interlocking.
  - c. Load shedding.
  - d. Load trimming.
6. System: Report equipment status and power system control.

### B. System Requirements

1. Monitoring and Control System: Include PC-based workstation **OR** multiple PC-based workstations **OR** multiple PC-based workstations with graphics capability and Web access, **as directed**, with its operating system and application software, connected to data transmission network.
2. Surge Protection: For external wiring of each conductor entry connection to components to protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads.
  - a. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
  - b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements as recommended by manufacturer for type of line being protected.
3. Addressable Devices: All transmitters and receivers shall communicate unique device identification and status reports to monitoring and control clients.



4. BAS Interface: Provide factory-installed hardware and software to enable the BAS to monitor, display, and record data for use in processing reports.
  - a. Hardwired Monitoring Points: Electrical power demand (kilowatts), electrical power consumption (kilowatt-hours), power factor, **as directed**.  
**OR**  
 ASHRAE 135 (BACnet) **OR** LonTalk **OR** Modbus **OR** Industry-accepted, open-protocol, **as directed**, communication interface with the BAS shall enable the BAS operator to remotely monitor meter information from a BAS operator workstation. Control features and monitoring points displayed locally at metering panel shall be available through the BAS.

C. Operating System

1. Software: Configured to run on a portable laptop computer, a single PC, or a palm computer, with capability for accessing a single meter at a time. System is not connected to a LAN. Modbus TCP/IP, RS-232, and RS-485 digital communications.  
**OR**  
 Software: Configured to run on a single PC, with capability for accessing multiple devices simultaneously. Modbus TCP/IP, RS-232, and RS-485 digital communications.  
**OR**  
 Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Ethernet, Modbus TCP/IP, RS-232, and RS-485 digital communications.  
**OR**  
 Software: Configured for a server and multiple client PCs, each with capability for accessing multiple devices simultaneously. Software shall include interactive graphics client and shall be Web enabled. Workstations and portable computers shall not require any software except for an Internet browser to provide connectivity and full functionality. Include a firewall recommended by manufacturer. 100 Base-T Ethernet, Modbus TCP/IP RS-232, and RS-485 digital communications.
2. Operating System Software: Based on 32-bit, Microsoft Windows workstation operating system. Software shall have the following features:
  - a. Multiuser and multitasking to allow independent activities and monitoring to occur simultaneously at different workstations.
  - b. Graphical user interface to show pull-down menus and a menu tree format.
  - c. Capability for future additions within the indicated system size limits.
3. Peer Computer Control Software: Shall detect a failure of workstation and associated server, **as directed**, and shall cause other workstation and associated server, **as directed**, to assume control of all system functions without interruption of operation. Drivers shall be provided in both central computers to support this mode of operation.

D. Applications Software

1. Basic Requirements:
  - a. Fully compatible with and based on the approved operating system.
  - b. Password-protected operator login and access; three levels, minimum.
  - c. Password-protected setup functions.
  - d. Context sensitive on-line help.
  - e. Capability of creating, deleting, and copying files; and automatically maintaining a directory of all files, including size and location of each sequential and random-ordered record.
  - f. Capability for importing custom icons into graphic views to represent alarms and I/O devices.
  - g. Automatic and encrypted backups for database and history; automatically stored at central control PC **OR** selected workstation, **as directed**, and encrypted with a nine-character alphanumeric password, which must be used to restore or read data contained in backup.
  - h. Operator audit trail for recording and reporting all changes made to user-defined system options.
2. Workstation Server Functions:



- a. Support other client PCs on the LAN and WAN, **as directed**.
  - b. Maintain recorded data in databases accessible from other PCs on the LAN and WAN, **as directed**.
3. Data Formats:
  - a. User-programmable export and import of data to and from commonly used Microsoft Windows spreadsheet, database, billing, and other applications; using dynamic data exchange technology.
  - b. Option to convert reports and graphics to HTML format.
  - c. Interactive graphics.
  - d. Option to send preprogrammed or operator designed e-mail reports.
4. Metered Data: Display metered values in real time.
5. Remote Control:
  - a. Display circuit-breaker status and allow breaker control.
  - b. User defined with load-shedding automatically initiated and executed schemes responding to programmed time schedules, set points of metered demands, utility contracted load shedding, or combinations of these.
6. Equipment Documentation: Database for recording of equipment ratings and characteristics; with capability for graphic display on monitors.
7. Graphics: Interactive color-graphics platform with pull-down menus and mouse-driven generation of power system graphics, in formats widely used for such drafting; to include the following:
  - a. Site plan.
  - b. Floor plans.
  - c. Equipment elevations.
  - d. Single-line diagrams.
8. User-Defined Monitoring and Control Events: Display and record with date and time stamps accurate to 0.1 second, and including the following:
  - a. Operator log on/off.
  - b. Attempted operator log on/off.
  - c. All alarms.
  - d. Equipment operation counters.
  - e. Out-of-limit, pickup, trip, and no-response events.
9. Trending Reports: Display data acquired in real-time from different meters or devices, in historical format over user-defined time; unlimited as to interval, duration, or quantity of trends.
  - a. Spreadsheet functions of sum, delta, percent, average, mean, standard deviation, and related functions applied to recorded data.
  - b. Charting, statistical, and display functions of standard Windows-based spreadsheet.
10. Alarms: Display and record alarm messages from discrete input and controls outputs, according to user programmable protocol.
  - a. Functions requiring user acknowledgment shall run in background during computer use for other applications and override other presentations when they occur.
11. Waveform Data: Display and record waveforms on demand or automatically on an alarm or programmed event; include the graphic displays of the following, based on user-specified criteria:
  - a. Phase voltages, phase currents, and residual current.
  - b. Overlay of three-phase currents, and overlay each phase voltage and current.
  - c. Waveforms ranging in length from 2 cycles to 5 minutes.
  - d. Disturbance and steady-state waveforms up to 512 points per cycle.
  - e. Transient waveforms up to 83,333 points per cycle on 60-Hz base.
  - f. Calculated waveform on a minimum of four cycles of data of the following:
    - 1) THD.
    - 2) rms magnitudes.
    - 3) Peak values.
    - 4) Crest factors.
    - 5) Magnitude of individual harmonics.
12. Data Sharing: Allow export of recorded displays and tabular data to third-party applications software.
13. Tenant or Activity Billing Software:

- a. Automatically compute and prepare tenant bills **OR** activity demand and energy-use statements, **as directed**, based on metering of energy use and peak demand integrated over user-defined interval.
  - b. Intervals shall be same as used by electric utilities, including current vendor.
  - c. Import metered data from saved records that were generated by metering and monitoring software.
  - d. Maintain separate directory for each tenant's historical billing information.
  - e. Prepare summary reports in user-defined formats and time intervals.
14. Reporting: User commands initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
  - a. Print a record of user-defined alarm, supervisory, and trouble events on workstation printer.
  - b. Sort and report by device name and by function.
  - c. Report type of signal (alarm, supervisory, or trouble), description, date, and time of occurrence.
  - d. Differentiate alarm signals from other indications.
  - e. When system is reset, report reset event with same information concerning device, location, date, and time.
- E. Communication Components And Networks
  1. Transient Voltage Surge Suppression and Electromagnetic-Interference Immunity: Include in solid-state equipment. Comply with IEEE C37.90.
  2. Network Configuration: High-speed, multi-access, open nonproprietary, industry standard communication protocol; LANs complying with EIA 485, 100 Base-T Ethernet, and Modbus TCP/IP.
- F. Power Monitors
  1. Separately mounted, permanently installed instrument for power monitoring and control.
    - a. Enclosure: NEMA 250, Type 1 **OR** 12, **as directed**.
  2. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
    - a. Indoor installation in non-air-conditioned **OR** nontemperature-controlled, **as directed**, spaces that have environmental controls to maintain ambient conditions of **0 to 122 deg F (minus 18 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
  3. rms Real-Time Measurements:
    - a. Current: Each phase, neutral, average of three phases, percent unbalance.
    - b. Voltage: Line-to-line each phase, line-to-line average of three phases, line-to-neutral each phase, line-to-neutral average of three phases, line-to-neutral percent unbalance.
    - c. Power: Per phase and three-phase total.
    - d. Reactive Power: Per phase and three-phase total.
    - e. Apparent Power: Per phase and three-phase total.
    - f. Power Factor: Per phase and three-phase total.
    - g. Displacement Power Factor: Per phase and three-phase total.
    - h. Frequency.
    - i. THD: Current and voltage.
    - j. Accumulated Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
    - k. Incremental Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
    - l. Conditional Energy: Real kWh, reactive kVARh, apparent kVAh (signed/absolute).
  4. Demand Current Calculations, per Phase, Three-Phase Average and Neutral:
    - a. Present.
    - b. Running average.
    - c. Last completed interval.
    - d. Peak.
  5. Demand Real Power Calculations, Three-Phase Total:

- a. Present.
- b. Running average.
- c. Last completed interval.
- d. Predicted.
- e. Peak.
- f. Coincident with peak kVA demand.
- g. Coincident with kVAR demand.
6. Demand Reactive Power Calculations, Three-Phase Total:
  - a. Present.
  - b. Running average.
  - c. Last completed interval.
  - d. Predicted.
  - e. Peak.
  - f. Coincident with peak kVA demand.
  - g. Coincident with kVAR demand.
7. Demand Apparent Power Calculations, Three-Phase Total:
  - a. Present.
  - b. Running average.
  - c. Last completed interval.
  - d. Predicted.
  - e. Peak.
  - f. Coincident with peak kVA demand.
  - g. Coincident with kVAR demand.
8. Average Power Factor Calculations, Demand Coincident, Three-Phase Total:
  - a. Last completed interval.
  - b. Coincident with kW peak.
  - c. Coincident with kVAR peak.
  - d. Coincident with kVA peak.
9. Power Analysis Values:
  - a. THD, Voltage and Current: Per phase, three phase, and neutral.
  - b. Displacement Power Factor: Per phase, three phase.
  - c. Fundamental Voltage, Magnitude and Angle: Per phase.
  - d. Fundamental Currents, Magnitude and Angle: Per phase.
  - e. Fundamental Real Power: Per phase, three phase.
  - f. Fundamental Reactive Power: Per phase.
  - g. Harmonic Power: Per phase, three phase.
  - h. Phase rotation.
  - i. Unbalance: Current and voltage.
  - j. Harmonic Magnitudes and Angles for Current and Voltages: Per phase, up to 31st **OR** 63<sup>rd</sup>, **as directed**, harmonic.
10. Power Demand Calculations: According to one of the following calculation methods, selectable by the user:
  - a. Thermal Demand: Sliding window updated every second for the present demand and at end of the interval for the last interval. Adjustable window that can be set in 1-minute intervals, from 1 to 60 minutes.
  - b. Block Interval with Optional Subintervals: Adjustable for 1-minute intervals, from 1 to 60 minutes. User-defined parameters for the following block intervals:
    - 1) Sliding block that calculates demand every second, with intervals less than 15 minutes, and every 15 seconds with an interval between 15 and 60 minutes.
    - 2) Fixed block that calculates demand at end of the interval.
    - 3) Rolling block subinterval that calculates demand at end of each subinterval and displays it at end of the interval.
  - c. Demand Calculation Initiated by a Synchronization Signal:
    - 1) Signal is a pulse from an external source. Demand period begins with every pulse. Calculation shall be configurable as either a block or rolling block calculation.

- 2) Signal is a communication signal. Calculation shall be configurable as either a block or rolling block calculation.
- 3) Demand can be synchronized with clock in the power meter.
11. Sampling:
  - a. Current and voltage shall be digitally sampled at a rate high enough to provide accuracy to 63rd harmonic of 60-Hz fundamental.
  - b. Power monitor shall provide continuous sampling at a rate of 128 samples per cycle on all voltage and current channels in the meter.
12. Minimum and Maximum Values: Record monthly minimum and maximum values, including date and time of record. For three-phase measurements, identify phase of recorded value. Record the following parameters:
  - a. Line-to-line voltage.
  - b. Line-to-neutral voltage.
  - c. Current per phase.
  - d. Line-to-line voltage unbalance.
  - e. Line-to-neutral voltage unbalance.
  - f. Power factor.
  - g. Displacement power factor.
  - h. Total power.
  - i. Total reactive power.
  - j. Total apparent power.
  - k. THD voltage L-L.
  - l. THD voltage L-N.
  - m. THD current.
  - n. Frequency.
13. Harmonic Calculation: Display and record the following:
  - a. Harmonic magnitudes and angles for each phase voltage and current through 31st **OR** 63<sup>rd</sup>, **as directed**, harmonic. Calculate for all three phases, current and voltage, and residual current. Current and voltage information for all phases shall be obtained simultaneously from same cycle.
  - b. Harmonic magnitude reported as a percentage of the fundamental or as a percentage of rms values, as selected by user.
14. Current and Voltage Ratings:
  - a. Designed for use with current inputs from standard instrument current transformers with 5-A secondary and shall have a metering range of 0-10 A.
  - b. Withstand ratings shall be not less than 15 A, continuous; 50 A, lasting over 10 seconds, no more frequently than once per hour; 500 A, lasting 1 second, no more frequently than once per hour.
  - c. Designed for use with voltage inputs from standard instrument potential transformers with a 120-V secondary.
15. Accuracy:
  - a. Comply with ANSI C12.20, Class 0.5; and IEC 60687, Class 0.5 for revenue meters.
  - b. Accuracy from Light to Full Rating:
    - 1) Power: Accurate to 0.25 percent of reading, plus 0.025 percent of full scale.
    - 2) Voltage and Current: Accurate to 0.075 percent of reading, plus 0.025 percent of full scale.
    - 3) Power Factor: Plus or minus 0.002, from 0.5 leading to 0.5 lagging.
    - 4) Frequency: Plus or minus 0.01 Hz at 45 to 67 Hz.
16. Waveform Capture:
  - a. Capture and store steady-state waveforms of voltage and current channels; initiated manually. Each capture shall be for 3 cycles, 128 data points for each cycle, allowing resolution of harmonics to 31st harmonic of basic 60 Hz.
  - b. Store captured waveforms in internal nonvolatile memory; available for PC display, archiving, and analysis.
17. Input: One digital input signal(s).

- a. Normal mode for on/off signal.
- b. Demand interval synchronization pulse, accepting a demand synchronization pulse from a utility demand meter.
- c. Conditional energy signal to control conditional energy accumulation.
18. Outputs:
  - a. Operated either by user command sent via communication link, or set to operate in response to user-defined alarm or event.
  - b. Closed in either a momentary or latched mode as defined by user.
  - c. Each output relay used in a momentary contact mode shall have an independent timer that can be set by user.
  - d. One digital KY pulse to a user-definable increment of energy measurement. Output ratings shall be up to 120-V ac, 300-V dc, 50 mA, and provide 3500-V rms isolation.
  - e. One relay output module(s), providing a load voltage range from 20- to 240-V ac or from 20- to 30-V dc, supporting a load current of 2 A.
  - f. Output Relay Control:
    - 1) Relay outputs shall operate either by user command sent via communication link or in response to user-defined alarm or event.
    - 2) Normally open and normally closed contacts, field configured to operate as follows:
      - a) Normal contact closure where contacts change state for as long as signal exists.
      - b) Latched mode when contacts change state on receipts of a pickup signal; changed state is held until a dropout signal is received.
      - c) Timed mode when contacts change state on receipt of a pickup signal; changed state is held for a preprogrammed duration.
      - d) End of power demand interval when relay operates as synchronization pulse for other devices.
      - e) Energy Pulse Output: Relay pulses quantities used for absolute kWh, absolute kVARh, kVAh, kWh In, kVARh In, kWh Out, and kVARh Out.
      - f) Output controlled by multiple alarms using Boolean-type logic.
19. Onboard Data Logging:
  - a. Store logged data, alarms, events, and waveforms in 80 **OR** 800, **as directed**, KB of onboard nonvolatile memory.
  - b. Stored Data:
    - 1) Billing Log: User configurable; data shall be recorded every 15 minutes, identified by month, day, and 15-minute interval. Accumulate 24 months of monthly data, 32 days of daily data, and between 2 to 52 days of 15-minute interval data, depending on number of quantities selected.
    - 2) Custom Data Logs: One **OR** Three, **as directed**, user-defined log(s) holding up to 96 parameters. Date and time stamp each entry to the second and include the following user definitions:
      - a) Schedule interval.
      - b) Event definition.
      - c) Configured as "fill-and-hold" or "circular, first-in first-out."
    - 3) Alarm Log: Include time, date, event information, and coincident information for each defined alarm or event.
    - 4) Waveform Log: Store captured waveforms configured as "fill-and-hold" or "circular, first-in first-out."
  - c. Default values for all logs shall be initially set at factory, with logging to begin on device power up.
20. Alarms.
  - a. User Options:
    - 1) Define pickup, dropout, and delay.
    - 2) Assign one of four severity levels to make it easier for user to respond to the most important events first.
    - 3) Allow for combining up to four alarms using Boolean-type logic statements for outputting a single alarm.

- b. Alarm Events:
      - 1) Over/undercurrent.
      - 2) Over/undervoltage.
      - 3) Current imbalance.
      - 4) Phase loss, current.
      - 5) Phase loss, voltage.
      - 6) Voltage imbalance.
      - 7) Over kW demand.
      - 8) Phase reversal.
      - 9) Digital input off/on.
      - 10) End of incremental energy interval.
      - 11) End of demand interval.
  - 21. Control Power: 90- to 457-V ac or 100- to 300-V dc.
  - 22. Communications:
    - a. Power monitor shall be permanently connected to communicate via Modbus TCP via a 100 Base-T Ethernet **OR** RS-485 Modbus TCP/IP, **as directed**.
    - b. Local plug-in connections shall be for RS-232 and 100 Base-T Ethernet.
  - 23. Display Monitor:
    - a. Backlighted LCD to display metered data with touch-screen **OR** touch-pad, **as directed**, selecting device.
    - b. Touch-screen display shall be a minimum 12-inch diagonal, resolution of 800 by 600 RGB pixels, 256 colors; NEMA 250, Type 1 display enclosure.
    - c. Display four values on one screen at same time.
      - 1) Current, per phase rms, three-phase average and neutral, **as directed**.
      - 2) Voltage, phase to phase, phase to neutral, and three-phase averages of phase to phase and phase to neutral.
      - 3) Real power, per phase and three-phase total.
      - 4) Reactive power, per phase and three-phase total.
      - 5) Apparent power, per phase and three-phase total.
      - 6) Power factor, per phase and three-phase total.
      - 7) Frequency.
      - 8) Demand current, per phase and three-phase average.
      - 9) Demand real power, three-phase total.
      - 10) Demand apparent power, three-phase total.
      - 11) Accumulated energy (MWh and MVARh).
      - 12) THD, current and voltage, per phase.
    - d. Reset: Allow reset of the following parameters at the display:
      - 1) Peak demand current.
      - 2) Peak demand power (kW) and peak demand apparent power (kVA).
      - 3) Energy (MWh) and reactive energy (MVARh).
- G. Standalone, Web-Enabled Monitoring And Control Instrument
  - 1. Separately mounted, permanently installed instrument for power monitoring and control.
    - a. Enclosure: NEMA 250, Type 1 **OR** 12, **as directed**.
  - 2. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability.
    - a. Indoor installation in non-air-conditioned **OR** nontemperature-controlled, **as directed**, spaces that have environmental controls to maintain ambient conditions of **0 to 122 deg F (minus 18 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
  - 3. Power-Distribution Equipment Monitor: Web enabled, with integral network port and embedded Web server with factory-configured firmware and HTML-formatted Web pages for viewing of power monitoring and equipment status information from connected devices equipped with digital communication ports.

4. LAN Connectivity: Multipoint, RS-485 Modbus serial communication network, interconnecting all breaker trip units, protective relays, drives, and metering devices equipped with communications. Serial communication network connected to Ethernet server that functions as a gateway and server, providing data access via 10 Base-T **OR** 100 Base-T **OR** 100 Base-FX, **as directed**, LAN.
5. Communication Devices within the Equipment: Addressed at factory and tested to verify reliable communication with network server.
6. Server Configuration:
  - a. Initial network parameters set using a standard Web browser. Connect via a local operator interface, or an RJ-45 port accessible from front of equipment.
  - b. Network server shall be factory programmed with embedded HTML-formatted Web pages that are user configurable and that provide detailed communication diagnostic information for serial and Ethernet ports as status of RS-485 network; with internal memory management information pages for viewing using a standard Web browser.
  - c. Login: Password protected; password administration accessible from the LAN using a standard Web browser.
  - d. Operating Software: Suitable for local access; firewall protected.
7. Data Access:
  - a. Network server shall include embedded HTML pages providing real-time information from devices connected to RS-485 network ports via a standard Web browser.
8. Equipment Monitoring Options: Login shall be followed by a main menu for selecting summary Web pages that follow.
9. Summary Web pages shall be factory configured to display the following information for each communicating device within the power equipment lineup:
  - a. User-Configured Custom Home Page: Provide for the lineup, showing status-at-a-glance of key operating values, **as directed**.
  - b. Circuit Summary Page: Circuit name, three-phase average rms current, power (kW), power factor, and breaker status.
  - c. Load Current Summary Page: Circuit name, Phase A, B, and C rms current values.
  - d. Demand Current Summary Page: Circuit name, Phase A, B, and C average demand current values.
  - e. Power Summary Page: Circuit name, present demand power (kW), peak demand power (kW), and recorded time and date.
  - f. Energy Summary Page: Circuit name, energy (kWh), reactive energy (kVARh), and time/date of last reset.
  - g. Transformer Status Page: Transformer tag, coil temperatures, and cooling fan status.
  - h. Motor-Control Center Status Page: Circuit name, three-phase average rms current, thermal capacity (percentage), and drive output frequency (Hz) contactor status.
  - i. Specific Device Pages: Each individual communicating device shall display detailed, real-time information, as appropriate for device type.
    - 1) Display historical energy data that shall be logged automatically for each device, as appropriate for device type.
    - 2) Display historical data logged from each device in graphical time-trend plots. Value to be displayed on time-trend plot shall be user selectable. Time interval to be displayed on scale shall be for previous day or week.
  - j. Export historical energy data to a PC or workstation through network using FTP (File Transfer Protocol). Format exported data in a CSV (Comma Separated Variable) file format for importing into spreadsheet applications.
10. Communications:
  - a. Power monitor: Permanently connected to communicate via RS-485 Modbus TCP/IP **OR** Modbus TCP via an 100 Base-T Ethernet, **as directed**.
  - b. Local Plug-in Connections: RS-232 and 100 Base-T Ethernet.
  - c. Monitor Display: Backlighted LCD to display metered data with touch-screen **OR** touch-pad, **as directed**, selecting device.

#### H. Workstation Hardware



1. Environmental Conditions: System components shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
  - a. Indoor installation in spaces that have environmental controls to maintain ambient conditions of **36 to 122 deg F (2 to 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
2. Computer: Standard unmodified PC of modular design. CPU word size shall be 32 bytes or larger; CPU operating speed shall be at least 66 MHz **OR** GHz, **as directed**.
  - a. Memory: 256 MB of usable installed memory, expandable to a minimum of 1024 MB without additional chassis or power supplies.
  - b. Real-Time Clock:
    - 1) Accuracy: Plus or minus 1 minute per month.
    - 2) Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; automatic reset by software.
    - 3) Clock shall function for one year without power.
    - 4) Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
  - c. Serial Ports: Two RS-232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
  - d. Parallel Port: Enhanced.
  - e. LAN Adapter Card: 10/100-Mbps PCI bus, internal network interface card.
  - f. Sound Card: For playback and recording of digital WAV sound files associated with audible warning and alarm functions.
  - g. Color Monitor: PC compatible, not less than **18 inches (455 mm)**, LCD type, with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm.
  - h. Keyboard: Minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
  - i. Mouse: Standard, compatible with installed software.
  - j. Disk Storage: Include the following, each with appropriate controller:
    - 1) Minimum 80-GB hard disk, maximum average access time of 10 ms.
    - 2) Floppy Disk Drive: High density, **3-1/2-inch (90-mm)** size.
    - 3) PCMCIA slot with removable 500-MB media.
    - 4) 100-MB Iomega Zip drive.
    - 5) 250-MB Iomega Jaz drive.
  - k. Magnetic Tape System, **as directed**: 4-mm cartridge magnetic tape system with minimum **2 OR 4 OR 12 OR 20, as directed**, -GB formatted capacity per tape. Provide 10 tapes, each in a rigid cartridge with spring-loaded cover and operator-selectable write-protect feature.
  - l. Modem: 56,600 bps, full duplex for asynchronous communications. With error detection, auto answer/autodial, and call-in-progress detection. Modem shall comply with requirements in ITU-T v.34, ITU-T v.42, ITU-T v.42 Appendix VI for error correction, and ITU-T v.42 BIS for data compression standards; and shall be suitable for operating on unconditioned voice-grade telephone lines complying with 47 CFR 68.
  - m. Audible Alarm: Manufacturer's standard.
  - n. CD-ROM Drive:
    - 1) Nominal Storage Capacity: 650 MB.
    - 2) Data Transfer Rate: 1.2 Mbps.
    - 3) Average Access Time: 150 ms.
    - 4) Cache Memory: 256 KB.
    - 5) Data Throughput: 1 MB/second, minimum.
  - o. Report Printer: Minimum resolution 600 dpi laser printer.
    - 1) Connected to central station and designated workstations.
    - 2) RAM: 2 MB, minimum.
    - 3) Printing Speed: Minimum 12 pages per minute.

- 4) Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.
- p. Interface: Bidirectional parallel and universal serial bus.
- q. LAN Adapter Card: 10/100-Mbps internal network interface card.
- 3. Redundant Central Computer: Connected in a hot standby, peer configuration; automatically maintains copies of system software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant computer in near real-time. If central computer fails, redundant computer shall assume control immediately and automatically.
- 4. UPS: Self-contained; complying with requirements in Division 26 Section "Static Uninterruptible Power Supply".
  - a. Size: Provide a minimum of 6 hours of operation of workstation station equipment, including 2 hours of alarm printer operation, **as directed**.
  - b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
  - c. Accessories:
    - 1) Transient voltage suppression.
    - 2) Input-harmonics reduction.
    - 3) Rectifier/charger.
    - 4) Battery disconnect device.
    - 5) Static bypass transfer switch.
    - 6) Internal maintenance bypass/isolation switch.
    - 7) External maintenance bypass/isolation switch.
    - 8) Output isolation transformer.
    - 9) Remote UPS monitoring.
    - 10) Battery monitoring.
    - 11) Remote battery monitoring.
- I. RS-232 ASCII Interface
  - 1. ASCII interface shall allow RS-232 connections to be made between a meter or circuit monitor operating as the host PC and any equipment that will accept RS-232 ASCII command strings, such as local display panels **OR** dial-up modems **OR** alarm transmitters, **as directed**.
  - 2. Pager System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
    - a. RS-232 output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to paging system. This interface shall support both numeric and alphanumeric pagers.
  - 3. Alarm System Interface:
    - a. RS-232 output shall be capable of transmitting alarms from other monitoring and alarm systems to workstation software.
  - 4. Cables:
    - a. PVC-Jacketed, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; PVC jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      - 1) NFPA 70, Type CM.
      - 2) Flame Resistance: UL 1581, Vertical Tray.
    - b. Plenum-Type, RS-232 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage; plastic jacket. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
      - 1) NFPA 70, Type CMP.
      - 2) Flame Resistance: NFPA 262, Flame Test.
- J. LAN Cables
  - 1. Comply with Division 27 Section "Communications Horizontal Cabling".

2. RS-485 Cable:
  - a. PVC-Jacketed, RS-485 Cable: Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
  - b. Plenum-Type, RS-485 Cable: Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket, and NFPA 70, Type CMP.
3. Unshielded Twisted Pair Cables: Category 5e **OR** 6, **as directed**, as specified for horizontal cable for data service in Division 27 Section "Communications Horizontal Cabling".

K. Low-Voltage Wiring

1. Low-Voltage Control Cable: Multiple conductor, color-coded, No. 20 AWG copper, minimum.
  - a. Sheath: PVC; except in plenum-type spaces, use sheath listed for plenums.
  - b. Ordinary Switching Circuits: Three conductors, unless otherwise indicated.
  - c. Switching Circuits with Pilot Lights or Locator Feature: Five conductors, unless otherwise indicated.

### 1.3 EXECUTION

A. Cabling

1. Comply with NECA 1.
2. Install cables and wiring according to requirements in Division 27 Section "Communications Horizontal Cabling".
3. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.  
**OR**  
Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
4. Install LAN cables using techniques, practices, and methods that are consistent with specified category rating of components and that ensure specified category performance of completed and linked signal paths, end to end.
5. Install cables without damaging conductors, shield, or jacket.

B. Identification

1. Identify components and power and control wiring according to Division 26 Section "Identification For Electrical Systems".
2. Label each power monitoring and control module with a unique designation.

C. Grounding

1. Comply with IEEE 1100, "Power and Grounding Sensitive Electronic Equipment."

D. Field Quality Control

1. Perform tests and inspections and prepare test reports.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
  - a. Electrical Tests: Use caution when testing devices containing solid-state components.
  - b. Continuity tests of circuits.
  - c. Operational Tests: Set and operate controls at workstation and at monitored and controlled devices to demonstrate their functions and capabilities. Use a methodical sequence that cues and reproduces actual operating functions as recommended by

manufacturer. Submit sequences for approval. Note response to each test command and operation. Note time intervals between initiation of alarm conditions and registration of alarms at central-processing workstation.

- 1) Coordinate testing required by this Section with that required by Sections specifying equipment being monitored and controlled.
  - 2) Test LANs according to requirements in Division 27 Section "Communications Horizontal Cabling".
  - 3) System components with battery backup shall be operated on battery power for a period of not less than 10 percent of calculated battery operating time.
  - 4) Verify accuracy of graphic screens and icons.
  - 5) Metering Test: Load feeders, measure loads on feeder conductor with an rms reading clamp-on ammeter, and simultaneously read indicated current on the same phase at central-processing workstation. Record and compare values measured at the two locations. Resolve discrepancies greater than 5 percent and record resolution method and results.
  - 6) Record metered values, control settings, operations, cues, time intervals, and functional observations and submit test reports printed by workstation printer.
3. Correct deficiencies, make necessary adjustments, and retest. Verify that specified requirements are met.
  4. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
  5. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.
  6. Remove and replace malfunctioning devices and circuits and retest as specified above.

E. Demonstration

1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain systems.
  - a. Train the Owner's management and maintenance personnel in interpreting and using monitoring displays and in configuring and using software and reports. Include troubleshooting, servicing, adjusting, and maintaining equipment. Provide a minimum of 12 hours' training.
  - b. Training Aid: Use approved final versions of software and maintenance manuals as training aids.

END OF SECTION 26 09 23 00b

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## SECTION 26 09 23 00c - MOTOR-CONTROL CENTERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for motor-control centers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes MCCs for use with ac circuits rated 600 V and less and having the following factory-installed components:
  - a. Incoming main lugs and OCPDs.
  - b. Full-voltage magnetic controllers.
  - c. Reduced-voltage magnetic controllers.
  - d. Reduced-voltage, solid-state controllers.
  - e. Multispeed controllers.
  - f. VFCs.
  - g. Feeder-tap units.
  - h. TVSS.
  - i. Instrumentation.
  - j. Auxiliary devices.

#### C. Definitions

1. BAS: Building automation system.
2. CE: Conformance Europeene (European Compliance).
3. CPT: Control power transformer.
4. EMI: Electromagnetic interference.
5. GFCI: Ground fault circuit interrupting.
6. IGBT: Insulated-gate bipolar transistor.
7. LAN: Local area network.
8. LED: Light-emitting diode.
9. MCC: Motor-control center.
10. MCCB: Molded-case circuit breaker.
11. MCP: Motor-circuit protector.
12. NC: Normally closed.
13. NO: Normally open.
14. OCPD: Overcurrent protective device.
15. PCC: Point of common coupling.
16. PID: Control action, proportional plus integral plus derivative.
17. PT: Potential transformer.
18. PWM: Pulse-width modulated.
19. RFI: Radio-frequency interference.
20. SCR: Silicon-controlled rectifier.
21. TDD: Total demand (harmonic current) distortion.
22. THD(V): Total harmonic voltage demand.
23. TVSS: Transient voltage surge suppressor.
24. VFC: Variable-frequency controller.

#### D. Performance Requirements

1. Seismic Performance: MCCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.



- a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

E. Submittals

1. Product Data: For each type of controller and each type of MCC. Include shipping and operating weights, features, performance, electrical ratings, operating characteristics, and furnished specialties and accessories.
2. LEED Submittals:
  - a. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.
3. Shop Drawings: For each MCC, manufacturer's approval, custom and production drawings as defined in UL 845. In addition to requirements specified in UL 845, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
  - a. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    - 1) Each installed unit's type and details.
    - 2) Factory-installed devices.
    - 3) Enclosure types and details.
    - 4) Nameplate legends.
    - 5) Short-circuit current (withstand) rating of complete MCC, and for bus structure and each unit.
    - 6) Features, characteristics, ratings, and factory settings of each installed controller and feeder device, and installed devices.
    - 7) Specified optional features and accessories.
  - b. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring for each installed controller.
  - c. Nameplate legends.
  - d. Vertical and horizontal bus capacities.
  - e. Features, characteristics, ratings, and factory settings of each installed unit.
4. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible **OR** designated, **as directed**, operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC **OR** at the defined PCC, **as directed**, to specified levels.
5. Standard Drawings: For each MCC, as defined in UL 845.
6. Production Drawings: For each MCC, as defined in UL 845.
7. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around MCCs where pipe and ducts are prohibited. Show MCC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
8. Seismic Qualification Certificates: For MCCs, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
9. Qualification Data: For qualified testing agency.
10. Product Certificates: For each MCC, from manufacturer.
11. Source quality-control reports.
12. Field quality-control reports.
13. Operation and Maintenance Data: For MCCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. Include the following:



- a. Manufacturer's Record Drawings: As defined in UL 845. In addition to requirements specified in UL 845, include field modifications and field-assigned wiring identification incorporated during construction by manufacturer, Contractor, or both.
  - b. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
  - c. Manufacturer's written instructions for setting field-adjustable overload relays.
  - d. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage, solid-state controllers.
  - e. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
  - f. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
14. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
  15. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.
  16. Warranty: Sample of special warranty.
- F. Quality Assurance
1. Testing Agency Qualifications: Member company of NETA or an NRTL.
    - a. Testing Agency's Field Supervisor: Currently certified by NETA **OR** one who meets the requirements necessary for certification, **as directed**, to supervise on-site testing.
  2. Source Limitations: Obtain MCCs and controllers of a single type from single source from single manufacturer.
  3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  4. Comply with NFPA 70.
  5. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
- G. Delivery, Storage, And Handling
1. Deliver MCCs in shipping splits of lengths that can be moved past obstructions in delivery paths.
  2. Handle MCCs according to the following:
    - a. NEMA ICS 2.3, "Instructions for the Handling, Installation, Operation, and Maintenance of Motor Control Centers Rated Not More Than 600 Volts."
    - b. NECA 402, "Recommended Practice for Installing and Maintaining Motor Control Centers."
  3. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside MCCs; install temporary electric heating, with at least 250 W per vertical section **OR** connect factory-installed space heaters to temporary electrical service, **as directed**.
- H. Project Conditions
1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
    - a. Ambient Temperature: Less than **0 deg F (minus 18 deg C)** or exceeding **104 deg F (40 deg C)**, with an average value exceeding **95 deg F (35 deg C)** over a 24-hour period.
    - b. Ambient Storage Temperature: Not less than minus **4 deg F (minus 20 deg C)** and not exceeding **140 deg F (60 deg C)**.
    - c. Humidity: Less than 95 percent (noncondensing).
    - d. Altitude: Exceeding **6600 feet (2000 m)**, or **3300 feet (1000 m)** if MCC includes solid-state devices.
  2. Interruption of Existing Electrical Service or Distribution Systems: Do not interrupt electrical service to, or distribution systems within, a facility occupied by the Owner or others unless



permitted under the following conditions, and then only after arranging to provide temporary electrical service according to requirements indicated:

- a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical service.
  - b. Indicate method of providing temporary electrical service.
  - c. Do not proceed with interruption of electrical service without the Owner's written permission.
  - d. Comply with NFPA 70E.
3. Product Selection for Restricted Space: Drawings indicate maximum dimensions for MCCs, including clearances between MCCs and adjacent surfaces and other items.

I. Coordination

1. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases.
2. Coordinate features of MCCs, installed units, and accessory devices with remote pilot devices and control circuits to which they connect.
3. Coordinate features, accessories, and functions of each MCC, each controller, and each installed unit with ratings and characteristics of supply circuits, motors, required control sequences, and duty cycle of motors and loads.

J. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace TVSS **OR** VFCs, **as directed**, that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period: Five years from date of Final Completion.

## 1.2 PRODUCTS

A. Manufactured Units

1. General Requirements for MCCs: Comply with NEMA ICS 18 and UL 845, **as directed**.

B. Functional Features

1. Description: Modular arrangement of main units, controller units, control devices, feeder-tap units, instruments, metering, auxiliary devices, and other items mounted in vertical sections of MCC.
2. Controller Units: Combination controller units.
  - a. Install units up to and including Size 3 on drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
  - b. Equip units in Type B and Type C MCCs with pull-apart terminal strips for external control connections.
3. Feeder-Tap Units: Through 225-A rating shall have drawout mountings with connectors that automatically line up and connect with vertical-section buses while being racked into their normal, energized positions.
4. Future Units: Compartments fully bused and equipped with guide rails or equivalent, ready for insertion of drawout units.
5. Spare Units: Installed in compartments indicated "spare."

C. Incoming Mains

1. Incoming Mains Location: Top and bottom, **as directed**.
2. Main Lugs Only: Conductor connectors suitable for use with conductor material and sizes.
  - a. Material: Tin-plated aluminum **OR** Hard-drawn copper, 98 percent conductivity, **as directed**.
  - b. Main and Neutral Lugs: Compression **OR** Mechanical, **as directed**, type.

3. MCCB: Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
  - a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  - c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
    - 1) Instantaneous trip.
    - 2) Long- and short-time pickup levels.
    - 3) Long- and short-time time adjustments.
    - 4) Ground-fault pickup level, time delay, and  $I^2t$  response.
  - d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  - e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
  - f. MCCB Features and Accessories:
    - 1) Standard frame sizes, trip ratings, and number of poles.
    - 2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.
    - 3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    - 4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    - 5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
    - 6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."
    - 7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
    - 8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
    - 9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
    - 10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
4. Insulated-Case Circuit Breaker: 80 **OR** 100, **as directed**, percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
  - a. Fixed **OR** Drawout, **as directed**, circuit-breaker mounting.
  - b. Two-step, stored-energy closing.
  - c. Standard **OR** Full, **as directed**, function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
    - 1) Instantaneous trip.
    - 2) Long- and short-time time adjustments.
    - 3) Ground-fault pickup level, time delay, and  $I^2t$  response.
  - d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
  - e. Remote trip indication and control.



- f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 16 Section "Electrical Power Monitoring and Control."
- g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- h. Control Voltage: 40-V dc **OR** 125-V dc **OR** 250-V dc **OR** 120-V ac, **as directed**.

D. Combination Controllers

1. Full-Voltage Controllers:
  - a. General Requirements for Full-Voltage Enclosed Controllers: Comply with NEMA ICS 2, general purpose, Class A.
  - b. Magnetic Controllers: Full voltage, across the line, electrically held.
    - 1) Configuration: Nonreversing and reversing.
2. Reduced-Voltage Magnetic Controllers:
  - a. General Requirements for Reduced-Voltage Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A; closed transition; adjustable time delay on transition.
  - b. Reduced-Voltage Magnetic Controllers: Reduced voltage, electrically held.
    - 1) Configuration:
      - a) Wye-Delta Controller: Four contactors, with a three-phase starting resistor/reactor bank.
      - b) Part-Winding Controller: Separate START and RUN contactors, field-selectable for one-half or two-thirds winding start mode, with either six- or nine-lead motors; with separate overload relays for starting and running sequences.
      - c) Autotransformer Reduced-Voltage Controller: Medium-duty service, with integral overtemperature protection; taps for starting at 50, 65, and 80 percent of line voltage; two START and one RUN contactors.
3. Reduced-Voltage, Solid-State Controllers:
  - a. General Requirements for Reduced-Voltage, Solid-State Controllers: Comply with UL 508.
  - b. Reduced-Voltage, Solid-State Controllers: An integrated unit with power SCRs, heat sink, microprocessor logic board, door-mounted digital display and keypad, bypass contactor, and overload relay; suitable for use with NEMA MG 1, Design B, polyphase, medium-induction motors.
    - 1) Configuration: Standard duty **OR** Severe duty, **as directed**; nonreversible **OR** reversible, **as directed**.
    - 2) Starting Mode: Voltage ramping **OR** Current limit **OR** Torque control **OR** Torque control with voltage boost, **as directed**; field selectable, **as directed**.
    - 3) Stopping Mode: Coast to stop **OR** Adjustable torque deceleration **OR** Adjustable braking, **as directed**; field selectable, **as directed**.
    - 4) Shorting (Bypass) Contactor: Operates automatically when full voltage is applied to motor, and bypasses the SCRs. Solid-state controller protective features shall remain active when the shorting contactor is in the bypass mode.
    - 5) Shorting and Input Isolation, **as directed**, Contactor Coils: Pressure-encapsulated type; manufacturer's standard operating voltage, matching control power or line voltage, depending on contactor size and line-voltage rating. Provide coil transient suppressors, **as directed**.
    - 6) Logic Board: Identical for all ampere ratings and voltage classes, with environmental protective coating.
    - 7) Adjustable acceleration-rate control using voltage or current ramp, and adjustable starting torque control with up to 400 percent current limitation for 20 seconds.
    - 8) SCR bridge shall consist of at least two SCRs per phase, providing stable and smooth acceleration with **OR** without, **as directed**, external feedback from the motor or driven equipment.

- 9) Keypad, front accessible; for programming the controller parameters, functions, and features; shall be manufacturer's standard and include not less than the following functions:
    - a) Adjusting motor full-load amperes, as a percentage of the controller's rating.
    - b) Adjusting current limitation on starting, as a percentage of the motor full-load current rating.
    - c) Adjusting linear acceleration and deceleration ramps, in seconds.
    - d) Initial torque, as a percentage of the nominal motor torque.
    - e) Adjusting torque limit, as a percentage of the nominal motor torque.
    - f) Adjusting maximum start time, in seconds.
    - g) Adjusting voltage boost, as a percentage of the nominal supply voltage.
    - h) Selecting stopping mode, and adjusting parameters.
    - i) Selecting motor thermal-overload protection class between 5 and 30.
    - j) Activating and de-activating protection modes.
    - k) Selecting or activating communications modes.
  - 10) Digital display, front accessible; for showing motor, controller, and fault status; shall be manufacturer's standard and include not less than the following:
    - a) Controller Condition: Ready, starting, running, stopping.
    - b) Motor Condition: Amperes, voltage, power factor, power, and thermal state.
    - c) Fault Conditions: Controller thermal fault, motor overload alarm and trip, motor underload, overcurrent, shorted SCRs, line or phase loss, phase reversal, and line frequency over or under normal.
  - 11) Controller Diagnostics and Protection:
    - a) Microprocessor-based thermal protection system for monitoring SCR and motor thermal characteristics, and providing controller overtemperature and motor overload alarm and trip; settings selectable via the keypad.
    - b) Protection from line-side reverse phasing; line-side and motor-side phase loss; motor jam, stall, and underload conditions; and line frequency over or under normal.
    - c) Input isolation contactor that opens when the controller diagnostics detect a faulted solid-state component, or when the motor is stopped.  
**OR**  
 Shunt trip that opens the disconnecting means when the controller diagnostics detect a faulted solid-state component.
  - 12) Remote Output Features:
    - a) All outputs prewired to terminal blocks.
    - b) Form C status contacts that change state when controller is running.
    - c) Form C alarm contacts that change state when a fault condition occurs.
  - 13) Optional Features:
    - a) Analog output for field-selectable assignment of motor operating characteristics; 0 to 10-V dc **OR** 4 to 20-mA dc, **as directed**.
    - b) Additional field-assignable Form C contacts for alarm outputs.
    - c) Surge suppressors in solid-state power circuits providing three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
    - d) Full-voltage bypass contactor operating automatically **OR** manually, with NORMAL/BYPASS selector switch, **as directed**. Power contacts shall be totally enclosed, double break, and silver-cadmium oxide; and assembled to allow inspection and replacement without disturbing line or load wiring.
4. Multispeed Magnetic Controllers:
- a. General Requirements for Multispeed Magnetic Controllers: Comply with NEMA ICS 2, general purpose, Class A.
  - b. Multispeed Magnetic Controllers: Two speed, full voltage, across the line, electrically held. Compelling relay to ensure that motor will start only at low speed.
    - 1) Configuration: Nonreversing **OR** Reversing, **as directed**; consequent pole **OR** two winding, **as directed**.

- 2) Compelling relays shall ensure that motor starts only at low speed.
  - 3) Accelerating timer relays shall ensure properly timed acceleration through speeds lower than that selected.
  - 4) Decelerating timer relays shall ensure automatically timed deceleration through each speed.
  - 5) Antiplugging timer relays shall ensure a time delay when transferring from FORWARD to REVERSE and back.
5. Disconnecting Means and OCPDs:
- a. Fusible Disconnecting Means:
    - 1) NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J **OR** Class L, **as directed**, fuses.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
  - b. MCP Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
    - 4) NC **OR** NO, **as directed**, alarm contact that operates only when MCP has tripped.
    - 5) Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.
  - c. MCCB Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
    - 2) Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    - 3) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 4) Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
    - 5) NC **OR** NO, **as directed**, alarm contact that operates only when MCCB has tripped.
  - d. Molded-Case Switch Disconnecting Means:
    - 1) UL 489, NEMA AB 1, and NEMA AB 3, with in-line fuse block for Class J or L power fuses (depending on ampere rating), providing an interrupting capacity to comply with available fault currents; MCCB with fixed, high-set instantaneous trip only.
    - 2) Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
    - 3) Auxiliary contacts "a" and "b" arranged to activate with molded-case switch handle.
    - 4) NC **OR** NO, **as directed**, alarm contact that operates only when molded-case switch has tripped.
6. Overload Relays:
- a. Melting-Alloy Overload Relays:
    - 1) Inverse-time-current characteristic.
    - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
    - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - b. Bimetallic Overload Relays:
    - 1) Inverse-time-current characteristic.
    - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
    - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    - 4) Ambient compensated.

- 5) Automatic resetting.
  - c. Solid-State Overload Relays:
    - 1) Switch or dial selectable for motor running overload protection.
    - 2) Sensors in each phase.
    - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
      - a) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
      - b) Analog communication module.
    - d. NC **OR** NO, **as directed**, isolated overload alarm contact.
    - e. External overload reset push button.
  7. Control Power:
    - a. Control Circuits: 24 **OR** 120, **as directed**, -V ac; obtained from integral CPT, with primary and secondary fuses, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
      - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
- E. VFCS
1. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C, **as directed**.
  2. Application: Constant torque and variable torque, **as directed**.
  3. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
    - a. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
    - b. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
    - c. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
    - d. Listed and labeled for single-phase use by an NRTL acceptable to authorities having jurisdiction.
  4. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
  5. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range **OR** 66 Hz, with torque constant as speed changes, **as directed**; maximum voltage equals input voltage.
  6. Unit Operating Requirements:
    - a. Input AC Voltage Tolerance: Plus 10 and minus 10 **OR** 15, **as directed**, percent of VFC input voltage rating.
    - b. Input AC Voltage Unbalance: Not exceeding 3 **OR** 5, **as directed**, percent.
    - c. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
    - d. Minimum Efficiency: 96 **OR** 97, **as directed**, percent at 60 Hz, full load.
    - e. Minimum Displacement Primary-Side Power Factor: 96 **OR** 98, **as directed**, percent under any load or speed condition.
    - f. Overload Capability: 1.1 **OR** 1.5, **as directed**, times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
    - g. Starting Torque: Minimum of 100 percent of rated torque from 3 to 60 Hz.
    - h. Speed Regulation: Plus or minus 5 **OR** 10, **as directed**, percent.
    - i. Output Carrier Frequency: Selectable; 0.5 to 15 kHz.



- j. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- 7. Inverter Logic: Microprocessor based, 16 **OR** 32, **as directed**, bit, isolated from all power circuits.
- 8. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
  - a. Signal: Electrical.  
**OR**  
Signal: Pneumatic.
- 9. Internal Adjustability Capabilities:
  - a. Minimum Speed: 5 to 25 percent of maximum rpm.
  - b. Maximum Speed: 80 to 100 percent of maximum rpm.
  - c. Acceleration: 0.1 to 999.9 seconds.
  - d. Deceleration: 0.1 to 999.9 seconds.
  - e. Current Limit: 30 to a minimum of 150 percent of maximum rating.
- 10. Self-Protection and Reliability Features:
  - a. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  - b. Loss of Input Signal Protection: Selectable response strategy including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
  - c. Under- and overvoltage trips.
  - d. Inverter overcurrent trips.
  - e. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
  - f. Critical frequency rejection, with three selectable, adjustable deadbands.
  - g. Instantaneous line-to-line and line-to-ground overcurrent trips.
  - h. Loss-of-phase protection.
  - i. Reverse-phase protection.
  - j. Short-circuit protection.
  - k. Motor overtemperature fault.
- 11. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- 12. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- 13. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- 14. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- 15. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- 16. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker **OR** NEMA AB 1, molded-case switch, with power fuse block and current-limiting fuses **OR** NEMA AB 1, thermal-magnetic circuit breaker **OR** NEMA KS 1, nonfusible switch, with power fuse block and current-limiting fuses **OR** NEMA KS 1, fusible switch, **as directed**, with pad-lockable, door-mounted handle mechanism.
  - a. Disconnect Rating (for VFCs without bypass systems): Not less than 115 percent of VFC input current rating.
  - b. Disconnect Rating (for VFCs with bypass systems): Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
  - c. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.

- d. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
- e. NC **OR** NO, **as directed**, alarm contact that operates only when circuit breaker has tripped.

F. VFC Controls And Indication

1. Status Lights: Door-mounted LED indicators displaying the following conditions:
  - a. Power on.
  - b. Run.
  - c. Overvoltage.
  - d. Line fault.
  - e. Overcurrent.
  - f. External fault.
2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
  - a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
  - b. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
    - 1) Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
3. Historical Logging Information and Displays:
  - a. Running log of total power versus time.
  - b. Total run time.
  - c. Fault log, maintaining last four faults with time and date stamp for each.
4. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters, including, but not limited to:
  - a. Output frequency (Hz).
  - b. Motor speed (rpm).
  - c. Motor status (running, stop, fault).
  - d. Motor current (amperes).
  - e. Motor torque (percent).
  - f. Fault or alarming status (code).
  - g. PID feedback signal (percent).
  - h. DC-link voltage (V dc).
  - i. Set point frequency (Hz).
  - j. Motor output voltage (V ac).
5. Control Signal Interfaces:
  - a. Electric Input Signal Interface:
    - 1) A minimum of two programmable analog inputs: 0- to 10-V dc **OR** 4- to 20-mA dc **OR** Operator-selectable "x"- to "y"-mA dc, **as directed**.
    - 2) A minimum of six multifunction programmable digital inputs.
  - b. Pneumatic Input Signal Interface: **3 to 15 psig (20 to 104 kPa)**.
  - c. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
    - 1) 0- to 10-V dc.
    - 2) 4- to 20-mA dc.
    - 3) Potentiometer using up/down digital inputs.
    - 4) Fixed frequencies using digital inputs.
  - d. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc **OR** 4- to 20-mA dc **OR** operator-selectable "x"- to "y"-mA dc, **as directed**), which can be configured for any of the following:
    - 1) Output frequency (Hz).
    - 2) Output current (load).

- 3) DC-link voltage (V dc).
  - 4) Motor torque (percent).
  - 5) Motor speed (rpm).
  - 6) Set point frequency (Hz).
  - e. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
    - 1) Motor running.
    - 2) Set point speed reached.
    - 3) Fault and warning indication (overtemperature or overcurrent).
    - 4) PID high- or low-speed limits reached.
  6. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
    - a. Number of Loops: One **OR** Two, **as directed**.
  7. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage, **as directed**. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.
    - a. Network Communications Ports: Ethernet and RS-422/485.
    - b. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet **OR** Echelon LonWorks **OR** Ethernet TCP/IP **OR** Johnson Metasys N2 **OR** Modbus/Memobus **OR** Siemens System 600 APOGEE **OR** an acceptable equivalent, **as directed**; protocols accessible via the communications ports.
- G. VFC Line Conditioning And Filtering
1. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD at input terminals of VFCs to less than 5 **OR** 8, **as directed**, percent and THD(V) to 3 **OR** 5, **as directed**, percent.
  2. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD and THD(V) at the defined PCC per IEEE 519.
  3. Input Line Conditioning: **<Insert requirements>**.
  4. VFC Output Filtering: **<Insert requirements>**.
  5. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.
- H. VFC Bypass Systems
1. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes, and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
  2. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.  
**OR**  
Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.
  3. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode, **as directed**.
    - a. Bypass Contactor: Load-break, IEC **OR** NEMA, **as directed**, -rated contactor.
    - b. Output Isolating Contactor: Non-load-break, IEC **OR** NEMA, **as directed**, -rated contactor.
    - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.

**OR**

Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier, **as directed**, arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.

- a. Bypass Contactor: Load-break, IEC **OR** NEMA, **as directed**, -rated contactor.
  - b. Input and Output Isolating Contactors: Non-load-break, IEC **OR** NEMA, **as directed**, -rated contactors.
  - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
4. Bypass Contactor Configuration: Full-voltage (across-the-line) **OR** Reduced-voltage (autotransformer), **as directed**, type.
- a. NORMAL/BYPASS selector switch.
  - b. HAND/OFF/AUTO selector switch.
  - c. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
  - d. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
    - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
    - 2) Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
  - e. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses **as directed**, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
  - f. CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.
5. Overload Relays: NEMA ICS 2.
- a. Melting-Alloy Overload Relays:
    - 1) Inverse-time-current characteristic.
    - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
    - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - b. Bimetallic Overload Relays:
    - 1) Inverse-time-current characteristic.
    - 2) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
    - 3) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    - 4) Ambient compensated.
    - 5) Automatic resetting.
  - c. Solid-State Overload Relays:
    - 1) Switch or dial selectable for motor-running overload protection.
    - 2) Sensors in each phase.
    - 3) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    - 4) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    - 5) Analog communication module.
    - 6) NC **OR** NO, **as directed**, isolated overload alarm contact.
    - 7) External overload reset push button.

I. Optional VFC Features

1. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications, when overload protection activates.

- a. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.
- b. Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.
- c. Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.
2. Damper control circuit with end of travel feedback capability.
3. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
4. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
5. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station **OR** smoke-control fan controller, **as directed**, this password-protected input:
  - a. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
  - b. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.  
**OR**  
Forces VFC to transfer to Bypass Mode and operate motor at full speed.
  - c. Causes display of Override Mode on the VFC display.
  - d. Reset VFC to normal operation on removal of override signal automatically **OR** manually, **as directed**.
6. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
7. Remote digital operator kit.
8. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

#### J. Feeder-Tap Units

1. MCCB: Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
  - a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
  - b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
  - c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
    - 1) Instantaneous trip.
    - 2) Long- and short-time pickup levels.
    - 3) Long- and short-time time adjustments.
    - 4) Ground-fault pickup level, time delay, and  $I^2t$  response.
  - d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
  - e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
  - f. MCCB Features and Accessories:
    - 1) Standard frame sizes, trip ratings, and number of poles.
    - 2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.
    - 3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.

- 4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
- 5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
- 6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring And Control".
- 7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
- 8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
- 9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
- 10) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
2. Fusible Switch: NEMA KS 1, Type HD, clips to accommodate specified fuses with lockable handle.
3. Fuses are specified in Division 26 Section "Fuses".

K. Transient Voltage Suppression Devices

1. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, wired-in **OR** plug-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the MCC short-circuit rating, and with the following features and accessories:
  - a. Fuses, rated at 200-kA interrupting capacity.
  - b. Fabrication using bolted compression lugs for internal wiring.
  - c. Integral disconnect switch.
  - d. Redundant suppression circuits.
  - e. Redundant replaceable modules.
  - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
  - g. LED indicator lights for power and protection status.
  - h. Audible alarm, with silencing switch, to indicate when protection has failed.
  - i. Form-C contacts rated at 5 A and 250-V ac, one NO and one NC, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
  - j. Four **OR** Six, **as directed**, -digit, transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**, -V, three-phase, four-wire circuits shall be as follows:
  - a. Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
  - b. Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
  - c. Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.

**OR**

Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:

- a. Line to Neutral: 400 V, 800 V from high leg.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

**OR**

Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:

- a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

## L. Instrumentation

1. Instrument Transformers (for the Owner metering): IEEE C57.13, NEMA EI 21.1, and the following:
  - a. PTs: IEEE C57.13; 120 V, 60 Hz, single **OR** tapped **OR** double, **as directed**, secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
  - b. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound **OR** bushing **OR** bar or window, **as directed**, type; single **OR** double, **as directed**, secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
  - c. CPTs: Dry type, mounted in separate compartments for units larger than 3 kVA.
  - d. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.
2. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
  - a. Listed or recognized by a nationally recognized testing laboratory.
  - b. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
  - c. Switch-selectable digital display of the following values with the indicated maximum accuracy tolerances:
    - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
    - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    - 4) Three-Phase Real Power (Megawatts): Plus or minus 2 percent.
    - 5) Three-Phase Reactive Power (Megavars): Plus or minus 2 percent.
    - 6) Power Factor: Plus or minus 2 percent.
    - 7) Frequency: Plus or minus 0.5 percent.
    - 8) Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
    - 9) Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
    - 10) Contact devices to operate remote impulse-totalizing demand meter.
  - d. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
  - a. Meters: **4-inch (100-mm)** diameter or **6 inches (150 mm)** square, flush or semiflush, with antiparallax 250-degree scale and external zero adjustment.
  - b. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
4. Instrument Switches: Rotary type with off position.
  - a. Voltmeter Switches: Permit reading of all phase-to-phase voltages and phase-to-neutral voltages where a neutral is included.
  - b. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.



5. Feeder Ammeters: **2-1/2-inch (64-mm)** minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for feeder circuits, unless otherwise indicated.
  6. Watt-Hour Meters and Wattmeters:
    - a. Comply with ANSI C12.1.
    - b. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
    - c. Suitable for connection to three- and four-wire circuits.
    - d. Potential indicating lamps.
    - e. Adjustments for light and full load, phase balance, and power factor.
    - f. Four-dial clock register.
    - g. Integral demand indicator.
    - OR**
    - h. Contact devices to operate remote impulse-totalizing demand meter.
    - i. Ratchets to prevent reverse rotation.
    - j. Removable meter with drawout test plug.
    - k. Semiflush mounted case with matching cover.
    - l. Appropriate multiplier tag.
  7. Impulse-Totalizing Demand Meter:
    - a. Comply with ANSI C12.1.
    - b. Suitable for use with MCC watt-hour meter, including two-circuit totalizing relay.
    - c. Cyclometer.
    - d. Four-dial, totalizing kilowatt-hour register.
    - e. Positive chart drive mechanism.
    - f. Capillary pen holding a minimum of one month's ink supply.
    - g. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
    - h. Capable of indicating and recording five **OR 15 OR 30, as directed**, -minute integrated demand of totalized system.
- M. MCC Control Power
1. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from CPT.  
**OR**  
Control Circuits: 120-V ac, supplied from remote branch circuit.
  2. Electrically Interlocked Main and Tie Circuit Breakers: Two CPTs in separate compartments, with interlocking relays, connected to the primary side of each CPT at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
  3. Control Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
  4. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
- N. Enclosures
1. Indoor Enclosures: Freestanding steel cabinets unless otherwise indicated. NEMA 250, Type 1 **OR Type 1A OR Type 2 OR Type 12, as directed**, unless otherwise indicated to comply with environmental conditions at installed location.
  2. Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
    - a. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point **OR Manual switching of branch-circuit protective device, as directed**.
    - b. Space-Heater Power Source: Transformer, factory installed in MCC **OR 120-V external branch circuit, as directed**.
  3. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray **OR custom color, as directed**, finish over a rust-inhibiting primer on treated metal surface.



4. Outdoor Enclosures: Type 3R, non-walk-in aisle **OR** Type 3R, with interior-lighted walk-in aisle, **as directed**.
  - a. Finish: Factory-applied finish in manufacturer's standard **OR** custom, **as directed**, color; undersurfaces treated with corrosion-resistant undercoating.
  - b. Enclosure: Flat **OR** Downward, rearward sloping, **as directed**, roof; bolt-on rear covers **OR** rear hinged doors, **as directed**, for each section, with provisions for padlocking.
  - c. Doors: Personnel door at each end of aisle, minimum width of **30 inches (762 mm)**; opening outwards; with panic hardware and provisions for padlocking **OR** cylinder lock, **as directed**.
  - d. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; GFCI duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
  - e. Walk-in Aisle Heating and Ventilating:
    - 1) Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of **40 deg F (5 deg C)** with outside design temperature of **104 deg F (40 deg C)**.
    - 2) Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of **100 deg F (38 deg C)** with outside design temperature of **23 deg F (minus 5 deg C)**.
    - 3) Ventilating openings complete with replaceable fiberglass air filters, **as directed**.
    - 4) Thermostat: Single stage; wired to control heat and exhaust fan.
  - f. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a CPT within the switchboard. Supply voltage shall be **120 OR 120/240 OR 120/208, as directed**, -V ac.  
**OR**  
Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.
5. Compartments: Modular; individual lift-off, **as directed**, doors with concealed hinges and quick-captive screw fasteners. Interlocks on units requiring disconnecting means in off position before door can be opened or closed, except by operating a permissive release device.
6. Interchangeability: Compartments constructed to allow for removal of units without opening adjacent doors, disconnecting adjacent compartments, or disturbing operation of other units in MCC; same size compartments to permit interchangeability and ready rearrangement of units, such as replacing three single units with a unit requiring three spaces, without cutting or welding.
7. Wiring Spaces:
  - a. Vertical wireways in each vertical section for vertical wiring to each unit compartment; supports to hold wiring in place.
  - b. Horizontal wireways in bottom **OR** top **OR** bottom and top, **as directed**, of each vertical section for horizontal wiring between vertical sections; supports to hold wiring in place.
- O. Auxiliary Devices
  1. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
    - a. Push Buttons, Pilot Lights, and Selector Switches: Heavy **OR** Standard, **as directed**, -duty, oiltight, **as directed**, type.
      - 1) Push Buttons: Covered **OR** Lockable **OR** Recessed **OR** Shielded **OR** Shrouded **OR** Unguarded, **as directed**, types; maintained **OR** momentary, **as directed**, contact unless otherwise indicated.
      - 2) Pilot Lights: Incandescent **OR** LED **OR** Neon **OR** Resistor **OR** Transformer, **as directed**, types; **<Insert color(s)>**; push to test, **as directed**.
      - 3) Selector Switches: Rotary type.
    - b. Elapsed-Time Meters: Heavy duty with digital readout in hours; nonresettable **OR** resettable, **as directed**.
    - c. Meters: Panel type, **2-1/2-inch (64-mm)** minimum size with 90- or 120-degree scale and plus or minus 2 percent accuracy with selector switches having an off position.
  2. NC **OR** NO **OR** Reversible NC/NO, **as directed**, contactor auxiliary contact(s).

3. Control Relays: Auxiliary and adjustable pneumatic **OR** solid-state, **as directed**, time-delay relays.
4. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
5. Space heaters, with NC auxiliary contacts, to mitigate condensation in enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
6. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
7. Cover gaskets for Type 1 enclosures.
8. Terminals for connecting power factor correction capacitors to the line **OR** load, **as directed**, side of overload relays.
9. Spare control-wiring terminal blocks; unwired **OR** wired, **as directed**.
10. Spare-Fuse Cabinet: Identified and compartmented steel box **OR** cabinet with hinged lockable door, **as directed**.

P. Characteristics And Ratings

1. Wiring: NEMA ICS 18, Class I **OR** Class I-S, **as directed**, Type A **OR** Type B, for starters above Size 3 **OR** Type B-D, for starter Size 3 and below **OR** Type B-T, for starter Size 3 and below **OR** Type C, **as directed**.  
**OR**  
Wiring: NEMA ICS 18, Class II **OR** Class II-S, **as directed**, Type B, for starters above Size 3 **OR** Type B-D, for starter Size 3 and below **OR** Type B-T, for starter Size 3 and below **OR** Type C, **as directed**.
2. Control and Load Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.
3. Nominal System Voltage: 480 V, three phase, three wire **OR** 480Y/277 V, three phase, four wire, **as directed**.  
**OR**  
Nominal System Voltage: 208 V, three phase, three wire **OR** 208/120 V, three phase, four wire, **as directed**.
4. Short-Circuit Current Rating for Each Unit: Combination series rated **OR** Fully rated, **as directed**; 22 **OR** 42 **OR** 65 **OR** 100, **as directed**, kA.
5. Short-Circuit Current Rating of MCC: Combination series rated **OR** Fully rated, **as directed**, with its main overcurrent device; 22 **OR** 42 **OR** 65 **OR** 100, **as directed**, kA.
6. Environmental Ratings:
  - a. Ambient Temperature Rating: Not less than 0 deg F (minus 18 deg C) and not exceeding 104 deg F (40 deg C), with an average value not exceeding 95 deg F (35 deg C) over a 24-hour period.
  - b. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C)
  - c. Humidity Rating: Less than 95 percent (noncondensing).
  - d. Altitude Rating: Not exceeding 6600 feet (2000 m), or 3300 feet (1000 m) if MCC includes solid-state devices.
7. Main-Bus Continuous Rating: 600 **OR** 800 **OR** 1000 **OR** 1200 **OR** 1600 **OR** 2000, **as directed**, A.
8. Vertical-Bus Minimum, **as directed**, Continuous Rating: 300 **OR** 600 **OR** 1200, **as directed**, A.
9. Horizontal and Vertical Bus Bracing (Short-Circuit Current Rating): Match MCC short-circuit current rating.
10. Main Horizontal and Equipment Ground Buses: Uniform capacity for entire length of MCC's main and vertical sections. Provide for future extensions from both ends, **as directed**. Brace bus extensions for busway feeder bus, **as directed**.
11. Vertical Phase and Equipment Ground Buses: Uniform capacity for entire usable height of vertical sections, except for sections incorporating single units.



12. Phase- and Neutral-, **as directed**, Bus Material: Hard-drawn copper of 98 percent conductivity, silver **OR** tin, **as directed**, plated.  
**OR**  
Phase- and Neutral-, **as directed**, Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy.
13. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus, **as directed**.  
**OR**  
Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus, **as directed**.
14. Ground Bus: Minimum size required by UL 845, hard-drawn copper of 98 percent conductivity, equipped with mechanical **OR** compression, **as directed**, connectors for feeder and branch-circuit equipment grounding conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run, **as directed**.
15. Front-Connected, Front-Accessible MCCs:
  - a. Main Devices: Drawout **OR** Fixed, **as directed**, mounted.
  - b. Controller Units: Drawout and fixed, **as directed**, mounted.
  - c. Feeder-Tap Units: Drawout and fixed, **as directed**, mounted.
  - d. Sections front and rear aligned.
16. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic MCC. Provide service entrance label and necessary applicable service entrance features.
17. the Owner Metering Compartment: A separate customer metering compartment and section with front hinged door, metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks, **as directed**.
18. Bus Transition and Incoming Pull Sections: Matched and aligned with basic MCC.
19. Pull Box on Top of an MCC:
  - a. Adequate ventilation to maintain temperature in pull box within same limits as MCC.
  - b. Set back from front to clear circuit-breaker removal mechanism.
  - c. Removable covers forming top, front, and sides. Top covers at rear easily removable for drilling and cutting.
  - d. Insulated bottom of fire-resistive material with separate holes for cable drops into MCC.
  - e. Cable supports arranged to facilitate cabling and adequate to support cables, including those for future installation.
  - f. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
20. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of unit.
21. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
22. Fungus Proofing: Permanent fungicidal treatment for OCPDs and other components including instruments and instrument transformers.

Q. Source Quality Control

1. MCC Testing: Inspect and test MCCs according to requirements in NEMA ICS 18.
2. VFC Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
  - a. Test each VFC while connected to its specified motor **OR** a motor that is comparable to that for which the VFC is rated, **as directed**.

- b. Verification of Performance: Rate VFCs according to operation of functions and features specified.
3. MCCs will be considered defective if they do not pass tests and inspections.
4. Prepare test and inspection reports.

### 1.3 EXECUTION

#### A. Examination

1. Examine areas and surfaces to receive MCCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.
2. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Harmonic Analysis Study

1. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible **OR** designated, **as directed**, operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at the defined PCC to specified levels.
2. Prepare a harmonic analysis study report complying with IEEE 399 and NETA Acceptance Testing Specification.

#### C. Installation

1. Coordinate layout and installation of MCCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Floor-Mounting Controllers: Install MCCs on **4-inch (100-mm)** nominal thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
5. Install fuses in each fusible switch.
6. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses".
7. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
8. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
9. Install power factor correction capacitors. Connect to the line **OR** load, **as directed**, side of overload relays. If connected to the load side of overload relays, adjust overload heater sizes to accommodate the reduced motor full-load currents.
10. Comply with NECA 1.

#### D. Identification

1. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for identification of MCC, MCC components, and control wiring.



- a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
    - b. Label MCC and each cubicle with engraved nameplate.
    - c. Label each enclosure-mounted control and pilot device.
    - d. Mark up a set of manufacturer's connection wiring diagrams with field-assigned wiring identifications and return to manufacturer for inclusion in Record Drawings.
  2. Operating Instructions: Frame printed operating instructions for MCCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of MCCs.
- E. Control Wiring Installation
1. Install wiring between enclosed controllers **OR** master terminal boards, **as directed**, and remote devices and facility's BAS **OR** and facility's central-control system, **as directed**. Comply with requirements in Division 26 Section "Control-voltage Electrical Power Cables".
  2. Bundle, train, and support wiring in enclosures.
  3. Connect selector switches and other automatic-control selection devices where applicable.
    - a. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switch is in manual-control position.
    - b. Connect selector switches within enclosed controller circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.
- F. Connections
1. Comply with requirements for installation of conduit in Division 26 Section "Raceway And Boxes For Electrical Systems". Drawings indicate general arrangement of conduit, fittings, and specialties.
  2. Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".
- G. Field Quality Control
1. Perform tests and inspections.
  2. Acceptance Testing Preparation:
    - a. Test insulation resistance for each enclosed controller, component, connecting supply, feeder, and control circuit.
    - b. Test continuity of each circuit.
  3. Tests and Inspections:
    - a. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
    - b. Test insulation resistance for each enclosed controller element, component, connecting motor supply, feeder, and control circuits.
    - c. Test continuity of each circuit.
    - d. Verify that voltages at controller locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify the Owner before starting the motor(s).
    - e. Test each motor for proper phase rotation.
    - f. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
    - g. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
    - h. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
      - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each multipole enclosed controller. Remove front panels so joints and connections are accessible to portable scanner.
      - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each multipole enclosed controller 11 months after date of Final Completion.

- 3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - i. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
    - j. Mark up a set of manufacturer's drawings with all field modifications incorporated during construction and return to manufacturer for inclusion in Record Drawings.
  4. Enclosed controllers will be considered defective if they do not pass tests and inspections.
  5. Prepare test and inspection reports, including a certified report that identifies enclosed controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- H. Startup Service
1. Perform startup service.
    - a. Complete installation and startup checks according to manufacturer's written instructions.
- I. Adjusting
1. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
  2. Adjust overload relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
  3. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify the Owner before increasing settings.
  4. Set the taps on reduced-voltage autotransformer controllers at 50 **OR** 65 **OR** 80, **as directed**, percent.
  5. Set field-adjustable switches and program microprocessors for required start and stop sequences in reduced-voltage, solid-state controllers.
  6. Program microprocessors in VFCs for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Final Completion.
  7. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".
- J. Protection
1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
  2. Replace controllers whose interiors have been exposed to water or other liquids prior to Final Completion.
- K. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers, and to use and reprogram microprocessor-based, reduced-voltage, solid-state controllers, **as directed**.

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## SECTION 26 09 23 00d - CENTRAL DIMMING CONTROLS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for central dimming controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes microprocessor-based central dimming controls with the following components:
  - a. Control network.
  - b. Master-control stations.
  - c. Partitioned-space master-control stations.
  - d. Wall stations.
  - e. Dimmer cabinets.
  - f. Manual switches and plates for controlling dimmers.

#### C. Definitions

1. Fade Override: The ability to temporarily set fade times to zero for all lighting scenes.
2. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
3. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.
4. Low Voltage: As defined in NFPA 70, term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.
5. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
6. SCR: Silicon-controlled rectifier.
7. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

#### D. Submittals

1. Product Data: For each type of product indicated.
  - a. For central dimming controls; include elevation, features, characteristics, and labels.
  - b. For dimmer panels; include dimensions, features, dimmer characteristics, ratings, and directories.
  - c. Device plates, plate color, and material.
  - d. Ballasts and lamp combinations compatible with dimmer controls.
  - e. Sound data including results of operational tests of central dimming controls.
  - f. Operational documentation for software and firmware.
2. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
  - a. Include elevation views of front panels of control and indicating devices and control stations.
  - b. Wiring Diagrams: Power, signal, and control wiring.
3. Samples: For master-control stations, partitioned-space master-control stations, wall stations, dimmer cabinets, and faceplates with factory-applied color finishes and technical features.
  - a. Operation and Maintenance Data: For central dimming controls with remote-mounting dimmers to include in emergency, operation, and maintenance manuals.
4. Warranty: Special warranty specified in this Section.



E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with 47 CFR 15, Subparts A and B, for Class A digital devices.
3. Comply with NFPA 70.

F. Warranty

1. Manufacturer's standard form in which manufacturer agrees to repair or replace components of central dimming controls that fail in materials or workmanship within specified warranty period.
  - a. Failures include, but are not limited to, the following:
    - 1) Damage from transient voltage surges.
  - b. Warranty Period: Cost to repair or replace any parts for two years from date of Final Completion.
  - c. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

G. Software Service Agreement

1. Services in this Article may not be allowed for publicly funded projects.
2. Technical Support: Beginning with Final Completion, provide software support for two years.
3. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
  - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

## 1.2 PRODUCTS

A. General System Requirements

1. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.
2. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state dimmers and control panels.
  - a. Alternative Line-Voltage Surge Suppression: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" for Category A **OR** B, **as directed**, locations.
3. Dimmers and Dimmer Modules: Comply with UL 508.
  - a. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
  - b. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

B. System Description

1. Description: Microprocessor-based, solid-state controls consisting of control stations and a separately mounted dimmer cabinet.
  - a. Operation: Change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a rocker switch **OR** pushbutton **OR** slider, **as directed**, is operated.
  - b. System control shall include master station(s), wall stations, and dimmer panels.
  - c. Each zone shall be configurable to control the following light sources:

- 1) Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
  - 2) Line-voltage incandescent lamps.
  - 3) Low-voltage incandescent lamps.
  - 4) Cold cathode lamps.
  - 5) Non-dimmed loads.
  - 6) LED lamps.
  - d. Control of each zone shall interface with controls for the following accessory functions:
    - 1) Curtains and drapes.
    - 2) Blackout curtains.
    - 3) Projector screens.
    - 4) Motorized partitions.
    - 5) Manually positioned partitions.
  - e. Memory: Retain preset scenes and fade settings through power failures for at least 90 days by retaining physical settings of controls or by an on-board, automatically recharged battery.
- C. Control Network
1. Dimmers shall receive signals from control stations that are linked to dimmer cabinet with a common network data cable.
  2. Functions of network control stations shall be set up at master station that include the number and arrangement of scene presets, zones, and fade times at wall stations.
    - a. Control Voltage: 24- or 10-V dc.
    - b. Comply with USITT AMX 192 **OR** USITT DMX 512, **as directed**, for data transmission.
- D. Master-Control Stations
1. Functions and Features:
    - a. Control adjustment of the lighting level for each scene of each zone, and adjustment of fade-time setting for each scene change from one preset scene to another. Controls shall use analog manual sliders **OR** digital rocker switches with LCD graphic display of light level, **as directed**.
    - b. Master channel shall raise and lower lighting level of all zones.
    - c. Fade rate for each scene shall be adjustable from zero to 60 seconds.
    - d. Fade override control for each scene.
    - e. Recall each preset scene and allow adjustment of zone controls associated with that scene.
    - f. Lockout switch to prevent changes when set.
    - g. On and off scene controls for non-dim channel contactors.
    - h. Emergency-control pushbutton to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
    - i. Master on and off switch; off position enables housekeeping controls.
    - j. Housekeeping controls to turn on selected lighting fixtures for housekeeping functions.
    - k. Pushbuttons for accessory functions.
    - l. Enable and disable wall stations.
    - m. Communications link to other master stations.
    - n. Provide for connecting a portable computer to program the master station.
    - o. Rear-illuminate all scene-select buttons.
    - p. Show lighting-level setting and fade-rate setting graphically using LEDs or backlighted bar-graph indicator.
  2. Mounting: Single, flush wall box with manufacturer's standard faceplate with hinged transparent locking cover, **as directed**.
- E. Partitioned-Space Master-Control Station
1. Functions and Features:
    - a. Automatically combine and separate lighting and accessory function controls as spaces are configured with movable partitions; with controls for adjustment of the lighting level for

- each scene of each dimmer, and adjustment of fade-rate setting for each scene change from one preset scene to another.
- b. Master controls shall accommodate partitioning the space into six adjacent rooms.
  - c. Manual controls to set up six scenes for each room. Include wall stations in each room to control scenes.
  - d. Master channel to raise and lower the lighting level of all zones.
  - e. Adjustable fade rate for each scene from zero to 60 seconds.
  - f. Fade override control for each scene.
  - g. On and off scene controls for non-dim channel contactors.
  - h. Emergency-control pushbutton to bypass all controls, turning all dimmers to full bright and turning on non-dim channel contactors.
  - i. Master on and off switch; off position enables housekeeping controls.
  - j. Housekeeping controls to turn on selected lighting fixtures for housekeeping functions.
  - k. Pushbuttons for accessory functions.
  - l. Provide for connecting a portable computer to program the master station.
  - m. Rear-illuminate all scene-select buttons.
  - n. Show lighting-level setting and fade-rate setting graphically using LEDs or backlighted bar-graph indicator.
2. Custom Graphics. Include a graphical display of room configurations and the names for each. Indicate the current spaces configuration with LCD graphic or LED-illuminated indicators, and show which wall stations are active. Inactive wall stations shall be automatically deactivated.
  3. Mounting: Single, flush wall box with manufacturer's standard faceplate with hinged transparent locking cover, **as directed**.

#### F. Wall Stations

1. Functions and Features:
  - a. Wall stations shall function as a submaster to a master station, containing limited control of selected scenes of the master station.
  - b. Controls to adjust the lighting level of each dimmer for each scene, and the fade time setting for each scene change from one preset scene to another.
  - c. Numbered pushbuttons to select scenes.
  - d. Off switch to turn master station off. Operating the off switch at any remote station shall automatically turn on selected housekeeping lighting, **as directed**.
  - e. On switch turns all scenes of master station to full bright.
  - f. Pushbutton controls for accessory functions.
2. Mounting: Flush, wall box with manufacturer's standard faceplate.
3. Hand-held Cordless Control: Scene-select and accessory function pushbuttons using infrared **OR** radio-frequency, **as directed**, transmission.

#### G. Dimmer Cabinets

1. Factory wired, convection cooled without fans, with barriers to accommodate 120- and 277-V feeders and suitable to control designated lighting equipment or accessory functions.
2. Ambient Conditions:
  - a. Temperature: 60 to 95 deg F (15 to 35 deg C).
  - b. Relative Humidity: 10 to 90 percent, noncondensing.
  - c. Filtered air supply.
3. Dimmer Cabinet Assembly: NRTL listed and labeled.
4. Cabinet Type: Plug in, modular, and accepting dimmers of each specified type in any plug-in position.
  - a. Integrated Fault-Current Rating: 10,000-A RMS symmetrical.
5. Lighting Dimmers: Solid-state SCR dimmers.
  - a. Primary Protection: Magnetic or thermal-magnetic circuit breaker, also serving as the disconnecting means.
  - b. Dimmer response to control signal shall follow the "Square Law Dimming Curve" specified in IESNA's "IESNA Lighting Handbook."

- c. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
    - d. Dimmed circuits shall be filtered to provide a minimum 350-mic.sec. current-rise time at a 90-degree conduction angle and 50 percent of rated dimmer capacity. Rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load-current waveform.
    - e. Protect controls of each dimmer with a fuse and transient voltage surge suppression, **as directed**.
  - 6. Non-dim modules shall include relays with contacts rated to switch 20-A tungsten-filament load at 120-V ac and 20-A electronic ballast load at 277-V ac.
  - 7. Accessory function control modules shall be compatible with requirement of the accessory being controlled.
  - 8. Digital Control Network:
    - a. Dimmers shall receive digital signals from digital network control stations that are linked to the dimmer cabinet with a common network data cable.
    - b. Functions of digital network control stations shall be set up at the dimmer cabinet's electronic controls that include indicated number and arrangement of scene presets, channels, and fade times.
  - 9. Emergency Power Transfer Switch: Comply with UL 1008; factory prewired and pretested to automatically transfer load circuits from normal to emergency power supply when normal supply fails.
    - a. Transfer from normal to emergency supply when normal-supply voltage drops to 55 percent or less.
    - b. Retransfer immediately to normal on failure of emergency supply and after an adjustable time-delay of 10 to 90 seconds on restoration of normal supply while emergency supply is available.
    - c. Integrated Fault-Current Rating: Same value as listed for the panel.
    - d. Test Switch: Simulate failure of normal supply to test controls associated with transfer scheme.
    - e. Fabricate and test dimmer boards to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
- H. Portable Computer
  - 1. Description: As recommended by master-control station manufacturer, to program master station and associated wall stations, and all interconnected master stations, **as directed**. Portable computer shall be laptop style with a battery runtime of at least two hours. Display shall be an 11-inch (280-mm) interactive-matrix LCD and shall have required hardware, firmware, and software to program specified control functions of master-control stations.
  - 2. Software shall be configured and customized by master-station manufacturer.
- I. Manual Switches And Plates
  - 1. Switches: Modular, momentary pushbutton, low-voltage type.
    - a. Color: White unless otherwise indicated.
    - b. Integral Pilot Light: Indicate when circuit is on. Use where indicated.
    - c. Locator Light: Internal illumination.
    - d. Wall Plates: Comply with requirements in Division 26 Section "Wiring Devices" for materials, finish, and color. Use multigang plates if more than one switch is indicated at a location.
    - e. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.
- J. Conductors And Cables
  - 1. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

2. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR 22 OR 24, as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
3. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 **OR 16 OR 18, as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
4. Unshielded, Twisted-Pair Data Cable: Category 5e **OR 6, as directed**. Comply with requirements in Division 27 Section "Communications Horizontal Cabling".

### 1.3 EXECUTION

#### A. Wiring Installation

1. Comply with NECA 1.
2. Wiring Method:
  - a. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables"
  - b. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Division 27 Section "Communications Horizontal Cabling".
  - c. Minimum conduit size shall be **1/2 inch (13 mm)**.
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
4. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
5. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
6. Install dimmer cabinets for each zone.

#### B. Identification

1. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for identifying components and power and control wiring.
2. Label each dimmer module with a unique designation.
3. Label each scene control button with approved scene description.

#### C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
  - a. Continuity tests of circuits.
  - b. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
    - 1) Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
  - c. Emergency Power Transfer: Test listed functions.
3. Remove and replace malfunctioning dimming control components and retest as specified above.
4. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
5. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

#### D. Demonstration



1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, the Owner's maintenance personnel to adjust, operate, and maintain central dimming controls. Laptop portable computer shall be used in training, **as directed**.
2. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls".

END OF SECTION 26 09 23 00d

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## SECTION 26 09 23 00e - MODULAR DIMMING CONTROLS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for modular dimming controls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Manual modular dimming controls.
  - b. Integrated, multipreset modular dimming controls.

#### C. Definitions

1. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.
2. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
3. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.
4. SCR: Silicon-controlled rectifier.
5. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

#### D. Submittals

1. Product Data: For each type of product indicated.
  - a. For modular dimming controls; include elevation, dimensions, features, characteristics, ratings, and labels.
  - b. Device plates and plate color and material.
  - c. Ballasts and lamp combinations compatible with dimmers.
  - d. Wiring Diagrams: Power, signal, and control wiring.
2. Samples: For master and remote-control stations, and faceplates with factory-applied color finishes and technical features.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

### 1.2 PRODUCTS

#### A. General Dimming Device Requirements

1. Compatibility: Dimming control components shall be compatible with other elements of lighting fixtures, ballasts, transformers, and lighting controls.
2. Dimmers and Dimmer Modules: Comply with UL 508.
  - a. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
  - b. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

**B. Manual Modular Multiscene Dimming Controls**

1. Description: Factory-fabricated equipment providing manual modular dimming control consisting of a wall-box-mounted, master-scene controller and indicated number of wall-box zone stations. Controls and dimmers shall be integrated for mounting in one-, two-, or three-gang wall box under a single wall plate. Each zone station shall be adjustable to indicated number of scenes, which shall be recorded on the zone controller.
2. Operation: Automatically change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
3. Each manual modular multiscene dimming controller shall include a master control and remote controls.
4. Each zone shall be configurable to control the following:
  - a. Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
  - b. Incandescent lamps.
  - c. Low-voltage incandescent lamps.
5. Memory: Retain preset scenes through power failures for at least seven days.
6. Device Plates: Style, material, and color shall comply with Division 26 Section "Wiring Devices".
7. Master-Scene Controller: Suitable for mounting in a single flush wall box.
  - a. Switches: Master off, group dim, group bright, and selectors for each scene.
  - b. LED indicator lights, one associated with each scene switch, and one for the master off switch.
8. Fluorescent Zone Dimmer: Suitable for operating lighting fixtures and ballasts specified in Division 26 Section "Interior Lighting", and arranged to dim number of scenes indicated for the master-scene controller. Scene selection is at the master-scene controller for setting light levels of each zone associated with scene.
  - a. Switch: Rocker **OR** Slider, **as directed**, style for setting the light level for each scene.
  - b. LED indicator lights, one associated with each scene.
  - c. Electrical Rating: 1000 **OR** 2000, **as directed**, VA, 120 V.
9. Incandescent Zone Dimmer: Suitable for operating incandescent lamps at line-voltage or low-voltage lamps connected to a transformer and arranged to dim number of scenes indicated for the master-scene controller. Scene selection shall be at the master-scene controller for setting light levels of each zone associated with scene.
  - a. Switch: Rocker **OR** Slider, **as directed**, style for setting the light level for each scene.
  - b. LED indicator lights, one associated with each scene.
  - c. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.

**C. Integrated, Multipreset Modular Dimming Controls**

1. Indicate number of wall-box, remote-control stations.
2. Description: Factory-fabricated, microprocessor-based, solid-state controls providing manual dimming control consisting of a master station and multiple wall-box, remote-control stations.
3. Operation: Automatically changes variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a push button is operated.
4. Each zone shall be configurable to control the following:
  - a. Fluorescent lamps with electronic **OR** magnetic, **as directed**, ballasts.
  - b. Incandescent lamps.
  - c. Low-voltage incandescent lamps.
5. Memory: Retain preset scenes and fade settings through power failures by retaining physical settings of controls.
6. Master Station:
  - a. Contains control panel and multiple control and dimmer modules.
  - b. Controls and commands adjustment of each dimmer-zone setting for each scene change from one preset scene to another.
    - 1) Master zone raises and lowers lighting level.
    - 2) Adjustable fade rate for each scene from 1 to 60 seconds.
  - c. Rear-illuminated, scene-select buttons.

- d. Lighting-level setting and fade-rate setting shall be graphically shown using LEDs or backlighting bar-graph indicator.
  - e. Mounting: Flush wall box with manufacturer's standard faceplate.
- 7. Remote-Control Stations:
  - a. Numbered push buttons to select scenes.
  - b. Off switch to turn master station off. Operating the off switch at any remote station shall automatically turn on selected housekeeping lighting, **as directed**.
  - c. On switch turns all scenes of master station to full bright.
  - d. Control Wiring: NFPA 70, Class 2.
  - e. Mounting: Single flush wall box with manufacturer's standard faceplate.
- 8. Infrared Remote-Control Station: Same functions as for standard remote-control station, except that functions are input by a hand-held infrared transmitter.
- 9. Dimmers: Modular, plug-in type, with circuit breaker to protect the dimmer and branch circuit.
  - a. Dimming Circuit: Two SCR dimmers, in inverse parallel configuration.
  - b. Dimming Curve: Modified "square law" as specified in IESNA's "IESNA Lighting Handbook"; control voltage is 0- to 10-V dc.
  - c. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
  - d. Voltage Regulation: Dimmer shall maintain a constant light level, with no visible flicker, when the source voltage varies plus or minus 2 percent in RMS voltage.
  - e. Short-Circuit Rating: 10 kA for 120 V, 14 kA for 277 V.
- D. Conductors And Cables
  - 1. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
  - 2. Class 2 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 **OR 22 OR 24, as directed**, AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

### 1.3 EXECUTION

- A. Wiring Installation
  - 1. Comply with NECA 1.
  - 2. Wiring Method: Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables". Minimum conduit size shall be **1/2 inch (13 mm)**.
  - 3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.
  - 4. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
  - 5. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
- B. Identification
  - 1. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for identifying components and power and control wiring.
  - 2. Label each dimmer module with a unique designation.
  - 3. Label each scene control button with approved scene description.
- C. Field Quality Control
  - 1. Perform tests and inspections and prepare test reports.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Tests and Inspections:
  - a. Continuity tests of circuits.
  - b. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.
    - 1) Include testing of modular dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.
3. Remove and replace malfunctioning modular dimming control components and retest as specified above.
4. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.
5. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

D. Demonstration

1. Engage a factory-authorized service representative to train **OR** Train, **as directed**, Owner's maintenance personnel to adjust, operate, and maintain modular dimming controls. Laptop portable computer shall be used in training, **as directed**.
2. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls".

END OF SECTION 26 09 23 00e



Task	Specification	Specification Description
26 09 23 00	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 09 23 00	02 84 16 00a	Interior Lighting
26 09 23 00	02 84 16 00b	Exterior Lighting

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## SECTION 26 11 13 00 - SECONDARY UNIT SUBSTATIONS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for secondary unit substations. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes indoor and outdoor secondary unit substations, each consisting of the following:
  - a. Primary incoming section.
  - b. Transformer.
  - c. Secondary distribution section.

#### C. Definitions

1. NETA ATS: Acceptance Testing Specification.

#### D. Submittals

1. Product Data: Include rated capacities, furnished specialties, and accessories.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Time-Current Characteristic Curves: For overcurrent protective devices.
4. Primary Fuses: Submit recommendations and size calculations.
5. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
6. Field quality-control test reports.
7. Operation and Maintenance Data: For secondary unit substations and accessories to include in emergency, operation, and maintenance manuals.

#### E. Quality Assurance

1. Electrical Components, Devices and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C2.
3. Comply with IEEE C37.121.
4. Comply with NFPA 70.

#### F. Delivery, Storage, And Handling

1. Deliver in shipping splits in sizes that can be moved past obstructions in delivery path.
2. Coordinate delivery of secondary unit substations to allow movement into designated space.
3. Store secondary unit substation components protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.
4. Handle secondary unit substation components according to manufacturer's written instructions. Use factory-installed lifting provisions.

#### G. Project Conditions

1. Service Conditions: IEEE C37.121, usual service conditions, except for the following:
  - a. Exposure to significant solar radiation.
  - b. Altitudes above 3300 feet (1000 m).

- c. Exposure to fumes, vapors, or dust.
- d. Exposure to explosive environments.
- e. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
- f. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
- g. Exposure to excessively high or low temperatures.
- h. Unusual transportation or storage conditions.
- i. Unusual grounding resistance conditions.
- j. Unusual space limitations.

## 1.2 PRODUCTS

### A. Manufactured Units

1. Indoor Unit Arrangement: Single assembly **OR** Separate secondary distribution equipment connected with busway, **as directed**.
2. Outdoor Unit Arrangement: Single assembly **OR** Separate secondary distribution equipment connected with busway, **as directed**.
  - a. Weatherproof, listed for installation outdoors, complying with IEEE C37.20.1.
  - b. Aisleless Construction: Full-height doors in front of basic weatherproof equipment.
3. Enclosure Finish: Factory-applied finish in manufacturer's standard color, including under surfaces treated with corrosion-resistant undercoating **OR** Factory-applied finish in manufacturer's standard gray over a rust-inhibiting primer on treated metal surface, **as directed**.

### B. Incoming Section

1. Primary Incoming Section: Terminal assembly with adequate space for incoming-cable terminations and surge arresters.  
**OR**  
Transformer cover-mounted bushings.  
**OR**  
Enclosed, air-interrupter, dual primary **OR** primary, **as directed**, switch.
  - a. Three pole, single throw, dead front, metal enclosed, with manual stored energy operator, with fuses mounted on a single frame **OR** without fuses, **as directed**, complying with IEEE C37.20.3.
  - b. Key interlocking system to prevent fuse access door from being opened unless switch is open. Additionally, interlock air-interrupter switch with transformer secondary main circuit breaker, preventing switch from being opened or closed unless secondary main circuit breaker is open.
  - c. Phase Barriers: Located between blades and fuses of each phase, designed for easy removal, allows visual inspection of switch components when barrier is in place.
  - d. Window: Permits viewing switch-blade positions when door is closed.
  - e. Accessory Set: Tools and miscellaneous items required for interrupter switchgear test, inspection, maintenance, and operation. Include fuse-handling tool as recommended by switchgear manufacturer.
  - f. Continuous-Current Rating: 600 A.
  - g. Short-Circuit Rating:
    - 1) Short-time momentary asymmetrical fault rating of 40 kA.
    - 2) 3-second symmetrical rating of 25-kA RMS.
    - 3) Fault close asymmetrical rating of 40 kA.
  - h. Fuses: Sizes recommended by secondary unit substation manufacturer, considering fan cooling, temperature-rise specification, and cycle loading. Comply with the following:
    - 1) Current-limiting type, rated for not less than 50-kA RMS symmetrical current-interrupting capacity.
    - 2) Indicator integral with each fuse to show when it has blown.

- 3) Spares: Include three fuses in use and three spare fuses in storage clips in each switch.
2. Surge Arresters: Comply with IEEE C62.11, Distribution class; metal-oxide-varistor type, with ratings as indicated, connected in each phase of incoming circuit and ahead of any disconnecting device.
- C. Liquid-Filled Transformer Section
  1. Description: IEEE C57.12.00 and UL 1062, liquid-filled, 2-winding, secondary unit substation transformer.
  2. Insulating Liquid: Mineral oil complying with ASTM D 3487, Type II, and tested according to ASTM D 117.  
**OR**  
Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.  
**OR**  
Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.  
**OR**  
Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.
  3. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12-percent kVA output, at 65 deg C temperature rise, without decreasing rated transformer life.  
**OR**  
Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.
  4. Basic Impulse Level: Comply with UL 1062.  
**OR**  
Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed**, kV.
  5. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.  
**OR**  
Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
  6. Cooling System: Class OA, liquid cooled **OR** OA/FA, liquid cooled, and with forced-air rating **OR** OA/FFA, liquid cooled, and with provisions for future forced-air rating, **as directed**. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.
  7. Sound level may not exceed 58 dB, without fans.
  8. Impedance: Percentage as directed.
  9. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:
    - a. Liquid-level gage.
    - b. Pressure-vacuum gage.
    - c. Liquid temperature indicator.
    - d. Drain and filter valves.
    - e. Pressure relief device.
- D. Dry-Type Transformer Section



1. Description: IEEE C57.12.01, IEEE C57.12.50 for dry-type transformers rated up to 500 kVA, IEEE C57.12.51 for dry-type transformers rated 501 kVA and larger, or IEEE C57.12.52 for sealed dry-type transformers rated 501 kVA and larger, NEMA ST 20, and dry-type, 2-winding, secondary unit substation transformer.
2. Enclosure: Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.  
**OR**  
Enclosure: Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, vacuum-pressure, impregnated type and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
3. Cooling System: Class AA, air cooled **OR** AA/FA, air cooled with forced-air rating **OR** AA/FFA, air cooled with provisions for future forced-air rating, **as directed**, complying with IEEE C57.12.01.
  - a. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
  - b. Include mounting provision for fans.
4. Insulation Materials: IEEE C57.12.01, rated 220 deg C.
5. Insulation Temperature Rise: 80 **OR** 115 **OR** 150, **as directed**, deg C, maximum rise above 40 deg C.
6. Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed**, kV.
7. Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.  
**OR**  
Full-Capacity Voltage Taps: 4 nominal 2.5 percent taps below rated primary voltage.
8. Sound level may not exceed maximum dBA level **as directed**, without fans operating.
9. Impedance: Percentage **as directed**.
10. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

E. Secondary Distribution Section

1. Secondary Terminal Compartment: Bus bars mounted on standoff insulators **OR** duct flange for close coupling with busway, **as directed**.  
**OR**  
Secondary Distribution: Low-voltage switchgear as specified in Division 26 Section "Low-voltage Switchgear".  
**OR**  
Secondary Distribution: Low-voltage switchboard as specified in Division 26 Section "Switchboards".  
**OR**  
Secondary Distribution: Motor-control center as specified in Division 26 Section "Motor-control Centers".  
**OR**  
Distribution Panelboard: Panelboards as specified in Division 26 Section "Panelboards".
2. Network Protectors:
  - a. Rated for continuous service in an ambient temperature of up to 40 deg C, applied to 3-phase, 4-wire, solidly grounded wye secondary networks. Comply with IEEE C57.12.44.
  - b. Dead-front, drawout design with externally mounted fuses, using hand-cranked rail system. Relay and control panel located on a separate drawout module.
  - c. Protector Operator: Spring-close and/or stored-energy mechanism, rated to close on a 25,000 **OR** 40,000, **as directed**, RMS symmetrical load.
  - d. Control Voltage: Not more than 125 V.

- e. Control microprocessor-based, three-phase, tripping relay with features and functions as follows:
    - 1) Close protector if positive sequence power flows into the network. Adjustable closing range shall be from 0.5 to 3.5 V in phase difference between network and transformer voltages.
    - 2) Trip protector if there is a net, three-phase, reverse power flow through protector. Trip protectors shall be adjustable from 0.05 to 5 percent of continuous-current rating of current transformers within protector.
    - 3) Trip protector if there is a flow of reverse magnetizing current of its associated transformer.
    - 4) Field-adjustable relay parameters and watt or watt-var trip values.
  - f. Protector shall not open under any fault on network side of protector.
  - g. Current-limiting fuses shall have interrupting capacity of 150,000 A on network side of protector for protection against switchboard bus faults.
  - h. Mechanical interlocks shall prevent racking in and racking out when protector is closed.
  - i. Auxiliary contacts shall be remotely tripped and locked out by four-wire remote pilot devices.
  - j. Network protectors shall have not less than two spare auxiliary dry contacts.
  - k. Network Switchgear-Mounted Disconnect Switch: Supply each network-protector circuit with a switchgear-mounted fuse truck, with Class L fuses rated for 200-kA interrupting capacity, and key interlocked with each associated protector.
- OR**
- Network Switchgear-Mounted Disconnect Switch: Supply each network-protector circuit with a switchgear-mounted main circuit breaker rated for fault current that can be delivered by the network transformers, less one. Use drawout type to provide a means of isolating the load side of each protector from the network bus.

**F. Identification Devices**

- 1. Compartment Nameplates: Engraved, laminated-plastic or metal nameplate for each compartment, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification For Electrical Systems".

**G. Source Quality Control**

- 1. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to IEEE C57.12.90. Conduct switchgear and switchboard tests according to ANSI C37.51.
- OR**
- Factory Tests: Perform the following factory-certified tests on each secondary unit substation:
- a. Resistance measurements of all windings on the rated voltage connection and on tap extreme connections.
  - b. Ratios on the rated voltage connection and on tap extreme connections.
  - c. Polarity and phase relation on the rated voltage connection.
  - d. No-load loss at rated voltage on the rated voltage connection.
  - e. Exciting current at rated voltage on the rated voltage connection.
  - f. Impedance and load loss at rated current on the rated voltage connection and on tap extreme connections.
  - g. Applied potential.
  - h. Induced potential.
  - i. Temperature Test: If a transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class FA rating.
    - 1) Temperature test is not required if a record of a temperature test on an essentially duplicate unit is available.
  - j. the Owner will witness all required factory tests. Notify the Owner at least 14 days before date of tests and indicate their approximate duration.



### 1.3 EXECUTION

#### A. Installation

1. Install secondary unit substations on concrete bases.
  - a. Anchor secondary unit substations to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Section "Hangers And Supports For Electrical Systems".
  - b. Construct concrete bases of dimensions indicated, but not less than 4 inches (100 mm) larger in both directions than supported unit and 4 inches (100 mm) high.
  - c. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
  - d. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around full perimeter of base.
  - e. Install epoxy-coated anchor bolts for anchoring equipment to the concrete base.
  - f. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - g. Bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.
2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

#### B. Identification

1. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification For Electrical Systems".
2. Operating Instructions: Frame printed operating instructions for secondary unit substations, including key interlocking, control sequences, elementary single-line diagram, and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of secondary unit substation.

#### C. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### D. Cleaning

1. After completing equipment installation and before energizing, inspect unit components. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish. Vacuum interiors of secondary unit substation sections.

#### E. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
2. Perform the following field tests and inspections and prepare test reports:
  - a. Perform each visual and mechanical inspection and electrical test according to NETA ATS. Certify compliance with test parameters.
  - b. After installing secondary unit substation but before primary is energized, verify that grounding system at the substation tested at the specified value or less.
  - c. After installing secondary unit substation and after electrical circuitry has been energized, test for compliance with requirements.
  - d. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
    - 1) Remove and replace malfunctioning units and retest as specified above.



F. Follow-Up Service

1. Voltage Monitoring and Adjusting: After Final Completion, if requested by the Owner, but not more than six months after Final Acceptance, perform the following voltage monitoring:
  - a. During a period of normal load cycles as evaluated by the Owner, perform seven days of three-phase voltage recording at the outgoing section of each secondary unit substation. Use voltmeters with calibration traceable to the National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from the nominal value by more than plus or minus 5 percent during the test period, is unacceptable.
  - b. Corrective Action: If test results are unacceptable, perform the following corrective action, as appropriate:
    - 1) Adjust transformer taps.
    - 2) Rebalance loads.
    - 3) Prepare written request for voltage adjustment by electric utility.
  - c. Retests: Repeat monitoring, after corrective action has been performed, until satisfactory results are obtained.
  - d. Report: Prepare a written report covering monitoring performed and corrective action taken.
2. Infrared Scanning: Perform as specified in Division 26 Section "Medium-voltage Switchgear".

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## SECTION 26 11 16 11 - SWITCHGEAR

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for switchgear. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes metal-enclosed, low-voltage power circuit-breaker switchgear rated 1000 V and less for use in ac systems.

#### C. Definitions

1. ATS: Acceptance Testing Service.
2. GFCI: Ground-fault circuit interrupter.

#### D. Submittals

1. Product Data: For each type of switchgear, circuit breaker, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: For each type of switchgear and related equipment.
  - a. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Include the following:
  - b. Wiring Diagrams: Power, signal, and control wiring.
3. Coordination Drawings: Floor plans showing dimensioned layout, required working clearances, and required area above and around switchgear where pipe and ducts are prohibited. Show switchgear layout and relationships between components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
4. Samples: Representative portion of mimic bus with specified finish. Manufacturer's color charts showing colors available for mimic bus.
5. Manufacturer Seismic Qualification Certification: Submit certification that switchgear, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
6. Field quality-control test reports.
7. Updated mimic-bus diagram reflecting field changes after final switchgear load connections have been made, for record.
8. Operation and Maintenance Data: For switchgear and components to include in emergency, operation, and maintenance manuals. Include the following:
  - a. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
  - b. Time-current curves, including selectable ranges for each type of overcurrent protective device.

#### E. Quality Assurance

1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
  - a. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.

2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
3. Comply with NFPA 70.

F. Delivery, Storage, And Handling

1. Deliver switchgear in sections of lengths that can be moved past obstructions in delivery path.
2. Store switchgear indoors in clean dry space with uniform temperature to prevent condensation. Protect switchgear from exposure to dirt, fumes, water, corrosive substances, and physical damage.
3. If stored in areas subjected to weather, cover switchgear to provide protection from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside switchgear; install electric heating (250 W per section) to prevent condensation.

G. Project Conditions

1. Installation Pathway: Remove and replace building components and structures to provide pathway for moving switchgear into place.
2. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service.
3. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchgear, including clearances between switchgear, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
4. Environmental Limitations: Rate equipment for continuous operation under the following conditions, unless otherwise indicated:
  - a. Ambient Temperature: Not exceeding 40 deg C.
  - b. Altitude: Not exceeding 6600 feet (2010 m).

## 1.2 PRODUCTS

A. Ratings

1. Nominal System Voltage: 480 V, 3 wire **OR** 480/277 V, 4 wire **OR** 240 V, 3 wire **OR** 208/120 V, 4 wire, **as directed**, 60 Hz.
2. Main-Bus Continuous: 4000 **OR** 3200 **OR** 2000 **OR** 1600, **as directed**, A.
3. Short-Time and Short-Circuit Current: Match rating of highest-rated circuit breaker in switchgear assembly.

B. Fabrication

1. Factory assembled and tested and complying with IEEE C37.20.1.
2. Indoor Enclosure Material: Steel.
3. Outdoor Enclosure Material: Galvanized steel.
4. Outdoor Enclosure Fabrication Requirements: Weatherproof; integral structural-steel base frame with factory-applied asphaltic undercoating; and each compartment equipped with the following features:
  - a. Structural design and anchorage adequate to resist loads imposed by 125-mph (200-km/h), **as directed**, wind.
  - b. Space heater operating at one-half or less of rated voltage, sized to prevent condensation.
  - c. Louvers equipped with insect and rodent screen and filter; arranged to permit air circulation while excluding insects, rodents, and exterior dust.
  - d. Hinged front door with padlocking provisions.
  - e. Interior light with switch.
  - f. Weatherproof duplex receptacle.

- g. Common internal aisle of sufficient width to permit protective-device withdrawal, disassembly, and servicing in aisle.
- h. Aisle access doors with outside padlocking provisions and interior panic latches.
- i. Aisle space heaters operating at one-half or less of rated voltage, thermostatically controlled.
- j. Vaporproof fluorescent aisle lights with low-temperature ballasts, controlled by wall switch at each entrance.
- k. GFCI duplex receptacles, a minimum of two, located in aisle.
- l. Aisle ventilation louvers equipped with insect and rodent screen and filter and arranged to permit air circulation while excluding insects, rodents, and exterior dust.
- 5. Finish: IEEE C37.20.1, manufacturer's standard gray finish over a rust-inhibiting primer on phosphatizing-treated metal surfaces.
- 6. Section barriers between main and tie circuit-breaker compartments shall be extended to rear of section.
- 7. Bus isolation barriers shall be arranged to isolate line bus from load bus at each main and tie circuit breaker.
- 8. Circuit-breaker compartments shall be equipped to house drawout-type circuit breakers and shall be fitted with hinged outer doors.
- 9. Fabricate enclosure with removable, hinged, rear cover panels to allow access to rear interior of switchgear.
- 10. Auxiliary Compartments: Match and align with basic switchgear assembly. Include the following:
  - a. Utility metering compartment that complies with utility company requirements.
  - b. Bus transition sections.
  - c. Incoming-line pull sections.
  - d. Hinged front panels for access to metering, accessory, and blank compartments.
  - e. Pull box on top of switchgear for extra room for pulling cable, with removable top, front, and side covers and ventilation provisions adequate to maintain air temperature in pull box within same limits as switchgear.
    - 1) Set pull box back from front to clear circuit-breaker lifting mechanism.
    - 2) Bottom: Insulating, fire-resistant material with separate holes for cable drops into switchgear.
    - 3) Cable Supports: Arranged to ease cabling and adequate to support cables indicated, including those for future installation.
- 11. Bus bars connect between vertical sections and between compartments. Cable connections are not permitted.
  - a. Main Phase Bus: Uniform capacity the entire length of assembly.
  - b. Neutral Bus: 50 **OR** 100, **as directed**, percent of phase-bus ampacity, except as indicated. Equip bus with pressure-connector terminations for outgoing circuit neutral conductors. Include braces for neutral-bus extensions for busway feeders.
  - c. Vertical Section Bus Size: Comply with IEEE C37.20.1, including allowance for spare circuit breakers and spaces for future circuit breakers.
  - d. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity, with copper feeder circuit-breaker line connections.  
**OR**  
 Phase- and Neutral-Bus Material: Silver- or tin-plated, high-strength, electrical-grade aluminum alloy, with copper or tin-plated aluminum circuit-breaker line connections.  
**OR**  
 Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent minimum conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
  - e. Use silver-plated copper or tin-plated aluminum for connecting circuit-breaker line to aluminum bus.
  - f. Use copper for connecting circuit-breaker line to copper bus.
  - g. Contact Surfaces of Buses: Silver plated.
  - h. Feeder Circuit-Breaker Load Terminals: Silver-plated copper bus extensions equipped with pressure connectors for outgoing circuit conductors.

- i. Ground Bus: Hard-drawn copper of 98 percent minimum conductivity, with pressure connector for feeder and branch-circuit ground conductors, minimum size **1/4 by 2 inches (6 by 50 mm)**.
- j. Supports and Bracing for Buses: Adequate strength for indicated short-circuit currents.
- k. Neutral bus equipped with pressure-connector terminations for outgoing circuit neutral conductors. Neutral-bus extensions for busway feeders are braced.
- l. Neutral Disconnect Link: Bolted, uninsulated, **1/4-by-2-inch (6-by-50-mm)** copper bus, arranged to connect neutral bus to ground bus.
- m. Provide for future extensions from either end of main phase, neutral, and ground bus by means of predrilled bolt-holes and connecting links.
- n. Bus-Bar Insulation: Individual bus bars wrapped with factory-applied, flame-retardant tape or spray-applied, flame-retardant insulation.
  - 1) Sprayed Insulation Thickness: **3 mils (0.08 mm)**, minimum.
  - 2) Bolted Bus Joints: Insulate with secure joint covers that can easily be removed and reinstalled.

### C. Components

- 1. Instrument Transformers: Comply with IEEE C57.13.
  - a. Potential Transformers: Secondary-voltage rating of 120 V and NEMA accuracy class of 0.3 with burdens of W, X, and Y.
  - b. Current Transformers: Ratios as indicated; burden and accuracy class suitable for connected relays, meters, and instruments.
- 2. Multifunction Digital-Metering Monitor: UL-listed or -recognized, microprocessor-based unit suitable for three- or four-wire systems and with the following features:
  - a. Inputs from sensors or 5-A current-transformer secondaries, and potential terminals rated to 600 V.
  - b. Switch-selectable digital display of the following:
    - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
    - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    - 4) Three-Phase Real Power: Plus or minus 2 percent.
    - 5) Three-Phase Reactive Power: Plus or minus 2 percent.
    - 6) Power Factor: Plus or minus 2 percent.
    - 7) Frequency: Plus or minus 0.5 percent.
    - 8) Integrated Demand, with Demand Interval Selectable from 5 to 60 Minutes: Plus or minus 2 percent.
    - 9) Accumulated energy, in megawatt hours (joules), plus or minus 2 percent; stored values unaffected by power outages for up to 72 hours.
  - c. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
- 3. Analog Instruments: Rectangular, **4-1/2-inch (115-mm)** square, accurate within 1 percent, semiflush mounting, with antiparallax 250-degree scale and external zero adjustment, complying with ANSI C39.1.
  - a. Voltmeters: Cover an expanded scale range of normal voltage plus 10 percent.
  - b. Voltmeter Selector Switch: Rotary type with off position to provide readings of phase-to-phase and phase-to-neutral voltages.
  - c. Ammeters: Cover an expanded scale range of bus rating plus 10 percent.
  - d. Ammeter Selector Switch: Permits current reading in each phase and keeps current-transformer secondary circuits closed in off position.
  - e. Locate meter and selector switch on circuit-breaker compartment door for indicated feeder circuits only.
  - f. Watt-Hour Meters: Flush- or semiflush-mounting type, 5 A, 120 V, 3 phase, 3 wire; with 3 elements, 15-minute indicating demand register, and provision for testing and adding pulse initiation.

- g. Recording Demand Meter: Usable as totalizing relay or indicating and recording maximum demand meter with 15-minute interval.
  - 1) Operation: Meter counts and records a succession of pulses entering two channels.
  - 2) Housing: Drawout, back-connected case arranged for semiflush mounting.
4. Relays: Comply with IEEE C37.90, types and settings as indicated; with test blocks and plugs.
5. Surge Arresters: Distribution class, metal-oxide-varistor type. Comply with IEEE C62.11 and NEMA LA 1.
  - a. Install in cable termination compartments and connect in each phase of circuit.
  - b. Coordinate rating with circuit voltage.
6. Provision for Future Devices: Equip compartments with rails, mounting brackets, supports, necessary appurtenances, and bus connections.
7. Fungus Proofing: Permanent fungicidal treatment for switchgear interior, including instruments and instrument transformers.
8. Control Power Supply: Control power transformer supplying 120-V control circuits through secondary disconnect devices. Include the following features:
  - a. Dry-type transformers, in separate compartments for units larger than 3 kVA, including primary and secondary fuses.
  - b. Two control power transformers in separate compartments with necessary interlocking relays; each transformer connected to line side of associated main circuit breaker.
    - 1) Secondary windings connected through a relay or relays to control bus to effect an automatic transfer scheme.
    - 2) Secondary windings connected through an internal automatic transfer switch to switchgear control power bus.
  - c. Control Power Fuses: Primary and secondary fuses with current-limiting and overload protection.
  - d. Fuses are specified in Division 26 Section "Fuses".
9. Control Wiring: Factory installed, complete with bundling, lacing, and protection; and complying with the following:
  - a. Flexible conductors for No. 8 AWG and smaller, for conductors across hinges and for conductors for interconnections between shipping units.
  - b. Conductors sized according to NFPA 70 for duty required.
- D. Circuit Breakers
  1. Description: Comply with IEEE C37.13.
  2. Ratings: As indicated for continuous, interrupting, and short-time current ratings for each circuit breaker; voltage and frequency ratings same as switchgear.
  3. Operating Mechanism: Mechanically and electrically trip-free, stored-energy operating mechanism with the following features:
    - a. Normal Closing Speed: Independent of both control and operator.
    - b. Slow Closing Speed: Optional with operator for inspection and adjustment.
    - c. Stored-Energy Mechanism: Manually charged **OR** Electrically charged, with optional manual charging, **as directed**.
    - d. Operation counter.
  4. Trip Devices: Solid-state, overcurrent trip-device system consisting of one or two current transformers or sensors per phase, a release mechanism, and the following features:
    - a. Functions: Long-time-delay, short-time-delay, and instantaneous-trip functions, independent of each other in both action and adjustment.
    - b. Temperature Compensation: Ensures accuracy and calibration stability from minus 5 to plus 40 deg C.
    - c. Field-adjustable, time-current characteristics.
    - d. Current Adjustability: Dial settings and rating plugs on trip units or sensors on circuit breakers, or a combination of these methods.
    - e. Three bands, minimum, for long-time- and short-time-delay functions; marked "minimum," "intermediate," and "maximum."
    - f. Pickup Points: Five minimum, for long-time- and short-time-trip functions. Equip short-time-trip function for switchable I<sup>2</sup>t operation.



- g. Pickup Points: Five minimum, for instantaneous-trip functions.
- h. Ground-fault protection with at least three short-time-delay settings and three trip-time-delay bands; adjustable current pickup. Arrange to provide protection for the following:
  - 1) Three-wire circuit or system.
  - 2) Four-wire circuit or system.
  - 3) Four-wire, double-ended substation.
- i. Trip Indication: Labeled, battery-powered lights or mechanical targets on trip device to indicate type of fault.
- 5. Auxiliary Contacts: For interlocking or remote indication of circuit-breaker position, with spare auxiliary switches and other auxiliary switches required for normal circuit-breaker operation, quantity as indicated. Each consists of two Type "a" and two Type "b" stages (contacts) wired through secondary disconnect devices to a terminal block in stationary housing.
- 6. Drawout Features: Circuit-breaker mounting assembly equipped with a racking mechanism to position circuit breaker and hold it rigidly in connected, test, and disconnected positions. Include the following features:
  - a. Interlocks: Prevent movement of circuit breaker to or from connected position when it is closed, and prevent closure of circuit breaker unless it is in connected, test, or disconnected position.
  - b. Circuit-Breaker Positioning: An open circuit breaker may be racked to or from connected, test, and disconnected positions only with the associated compartment door closed unless live parts are covered by a full dead-front shield. An open circuit breaker may be manually withdrawn to a position for removal from the structure with the door open. Status for connection devices for different positions includes the following:
    - 1) Test Position: Primary disconnect devices disengaged, and secondary disconnect devices and ground contact engaged.
    - 2) Disconnected Position: Primary and secondary devices and ground contact disengaged.
- 7. Arc Chutes: Readily removable from associated circuit breaker when it is in disconnected position, and arranged to permit inspection of contacts without removing circuit breaker from switchgear.
- 8. Padlocking Provisions: For installing at least three padlocks on each circuit breaker to secure its enclosure and prevent movement of drawout mechanism.
- 9. Operating Handle: One for each circuit breaker capable of manual operation.
- 10. Electric Close Button: One for each electrically operated circuit breaker.
- 11. Mechanical Interlocking of Circuit Breakers: Uses a mechanical tripping lever or equivalent design and electrical interlocks.
- 12. Key Interlocks: Arranged so keys are attached at devices indicated. Mountings and hardware are included where future installation of key-interlock devices is indicated.
- 13. Undervoltage Trip Devices: Instantaneous, with adjustable pickup voltage **OR** Adjustable time-delay and pickup voltage, **as directed**.
- 14. Shunt-Trip Devices: Where indicated.
- 15. Fused Circuit Breakers: Circuit breaker and fuse combinations complying with requirements for circuit breakers and trip devices and with the following:
  - a. Fuses: NEMA FU 1, Class L current limiting, sized to coordinate with and protect associated circuit breaker.
  - b. Circuit Breakers with Frame Size 1600 A and Smaller: Fuses on line side of associated circuit breaker, on a common drawout mounting, arranged so fuses are accessible only when circuit breaker is in disconnected position.
  - c. Circuit Breakers with Frame Sizes More Than 1600 A: Fuses and circuit breakers may be installed in separate compartments on separate drawout mountings. Fuse drawout element is interlocked with associated power circuit breaker to prevent drawing out fuse element unless circuit breaker is in open position.
  - d. Open-Fuse Trip Device: Positive means of tripping and holding circuit breaker in open position when a fuse opens. Open-fuse status is indicated at front of circuit breaker or fuse drawout element.

16. Indicating Lights: To indicate circuit breaker is open or closed, for main and bus tie circuit breakers interlocked either with each other or with external devices.

E. Accessories

1. Accessory Set: Furnish tools and miscellaneous items required for circuit-breaker and switchgear test, inspection, maintenance, and operation.
  - a. Racking handle to manually move circuit breaker between connected and disconnected positions.
  - b. Portable test set for testing all functions of circuit-breaker, solid-state trip devices without removal from switchgear.
  - c. Relay and meter test plugs suitable for testing switchgear meters and switchgear class relays.
2. Circuit-Breaker Removal Apparatus: Portable, floor-supported, roller-base, elevating carriage arranged for moving circuit breakers in and out of compartments.
3. Circuit-Breaker Removal Apparatus: Overhead-circuit-breaker lifting device, track mounted at top front of switchgear and complete with hoist and lifting yokes matching each size of drawout circuit breaker installed.
4. Spare-Fuse Cabinet: Identified and compartmented steel box or cabinet with lockable door.
5. Storage for Manual: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.

F. Identification

1. Mimic Bus: Continuous mimic bus, arranged in single-line diagram format, using symbols and lettered designations consistent with approved mimic-bus diagram.
  - a. Mimic-bus segments coordinated with devices in switchgear sections to which applied, to produce a concise visual presentation of principal switchgear components and connections.
  - b. Medium: Painted graphics, as selected by Architect.
  - c. Color: Contrasting with factory-finish background; as selected by Architect from manufacturer's full range.
2. System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads. Include as-built data for low-voltage power switchgear and connections as follows:
  - a. Frame size of each circuit breaker.
  - b. Trip rating for each circuit breaker.
  - c. Conduit and wire size for each feeder.

### 1.3 EXECUTION

A. Installation

1. Comply with applicable portions of NECA 400.
2. Anchor switchgear assembly to **4-inch (100-mm)**, channel-iron floor sill embedded in floor **OR** concrete base, **as directed**, and attach by bolting.
  - a. Sills: Select to suit switchgear; level and grout flush into floor **OR** concrete base, **as directed**.
  - b. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Hangers And Supports For Electrical Systems" for seismic-restraint requirements.
  - c. Concrete Bases: **4 inches (100 mm)** high, reinforced, with chamfered edges. Extend base no more than **3 inches (75 mm)** in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Hangers And Supports For Electrical Systems".
3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, brackets, and temporary blocking of moving parts from switchgear units and components.



- B. Identification
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section "Identification For Electrical Systems".
  2. Diagram and Instructions:
    - a. Frame and mount under clear acrylic plastic on the front of switchgear.
      - 1) Operating Instructions: Printed basic instructions for switchgear, including control and key-interlock sequences and emergency procedures.
      - 2) System Power Riser Diagrams: Depict power sources, feeders, distribution components, and major loads.
    - b. Storage for Maintenance: Include a rack or holder, near the operating instructions, for a copy of maintenance manual.
- C. Connections
1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- D. Field Quality Control
1. Prepare for acceptance tests as follows:
    - a. Test insulation resistance for each switchgear bus, component, connecting supply, feeder, and control circuit.
    - b. Test continuity of each circuit.
  2. Manufacturer's Field Service: Engage a factory-authorized service representative to perform the following:
    - a. Inspect switchgear installation, including wiring, components, connections, and equipment. Test and adjust components and equipment.
    - b. Verify that electrical control wiring installation complies with manufacturer's submittal by means of point-to-point continuity testing. Verify that wiring installation complies with requirements in Division 22.
    - c. Complete installation and startup checks according to manufacturer's written instructions.
    - d. Assist in field testing of equipment including pretesting and adjusting of equipment and components.
    - e. Report results in writing.
  3. Testing Agency: Engage a qualified independent testing and inspecting agency to perform field tests and inspections and prepare test reports.
    - a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters. Perform NETA tests and inspections for each of the following NETA categories:
      - 1) Switchgear.
      - 2) Circuit breakers.
      - 3) Protective relays.
      - 4) Instrument transformers.
      - 5) Metering and instrumentation.
      - 6) Ground-fault systems.
      - 7) Battery systems.
      - 8) Surge arresters.
      - 9) Capacitors.
    - b. Remove and replace malfunctioning units and retest as specified above.
  4. Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchgear. Remove front and rear panels so joints and connections are accessible to portable scanner.
    - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchgear 11 months after date of Final Completion.

- b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - c. Record of Infrared Scanning: Prepare a certified report that identifies switchgear checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- E. Adjusting
  - 1. Set field-adjustable, protective-relay trip characteristics according to results in Division 26 Section "Overcurrent Protective Device Coordination Study".
  - 2. Set field-adjustable, protective-relay trip characteristics.
- F. Cleaning
  - 1. On completion of installation, inspect interior and exterior of switchgear. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.
- G. Protection
  - 1. Temporary Heating: Apply temporary heat to switchgear, according to manufacturer's written instructions, throughout periods when switchgear environment is not controlled for temperature and humidity within manufacturer's stipulated service conditions.

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Task	Specification	Specification Description
26 11 16 11	26 11 13 00	Secondary Unit Substations

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## SECTION 26 12 13 00 - MEDIUM-VOLTAGE TRANSFORMERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for medium-voltage transformers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following types of transformers with medium-voltage primaries:
  - a. Liquid-filled distribution and power transformers.
  - b. Dry-type distribution and power transformers.
  - c. Pad-mounted, liquid-filled transformers.

#### C. Definitions

1. NETA ATS: Acceptance Testing Specification.

#### D. Submittals

1. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, location of each field connection, and performance for each type and size of transformer indicated.
2. Shop Drawings: Diagram power signal and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that transformer assembly and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Field quality-control test reports.
5. Follow-up service reports.
6. Operation and Maintenance Data: For transformer and accessories to include in emergency, operation, and maintenance manuals.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C2.
3. Comply with ANSI C57.12.10, ANSI C57.12.28, IEEE C57.12.70, and IEEE C57.12.80.
4. Comply with NFPA 70.

#### F. Delivery, Storage, And Handling

1. Store transformers protected from weather and so condensation will not form on or in units. Provide temporary heating according to manufacturer's written instructions.

#### G. Project Conditions

1. Service Conditions: IEEE C37.121, usual service conditions except for the following:
  - a. Exposure to significant solar radiation.
  - b. Altitudes above 3300 feet (1000 m).
  - c. Exposure to fumes, vapors, or dust.
  - d. Exposure to explosive environments.
  - e. Exposure to hot and humid climate or to excessive moisture, including steam, salt spray, and dripping water.
  - f. Exposure to seismic shock or to abnormal vibration, shock, or tilting.
  - g. Exposure to excessively high or low temperatures.



- h. Unusual transportation or storage conditions.
- i. Unusual grounding-resistance conditions.
- j. Unusual space limitations.

## 1.2 PRODUCTS

### A. Liquid-Filled Distribution And Power Transformers

1. Description: IEEE C57.12.00 and UL 1062, liquid-filled, 2-winding transformers.
2. Insulating Liquid: Mineral oil, complying with ASTM D 3487, Type II, and tested according to ASTM D 117.  
**OR**  
 Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.  
**OR**  
 Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.  
**OR**  
 Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.
3. Insulation Temperature Rise: 65/55 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C. Insulation system shall be rated to continuously allow an additional 12 percent kilovolt-ampere output, at 65 deg C temperature rise, without decreasing rated transformer life.  
**OR**  
 Insulation Temperature Rise: 65 deg C, based on an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C.
4. Basic Impulse Level: Comply with UL 1062.  
**OR**  
 Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed** kV.
5. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.  
**OR**  
 Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage, with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
6. Cooling System: Class OA, self-cooled **OR** OA/FA, self-cooled, and with forced-air-cooled rating **OR** OA/FFA, self-cooled, and with provisions for future forced-air-cooled rating, **as directed**. Cooling systems shall include auxiliary cooling equipment, automatic controls, and status indicating lights.
7. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.
8. Accessories: Grounding pads, lifting lugs, and provisions for jacking under base. Transformers shall have a steel base and frame allowing use of pipe rollers in any direction, and an insulated, low-voltage, neutral bushing with removable ground strap. Include the following additional accessories:
  - a. Liquid-level gage.
  - b. Pressure-vacuum gage.
  - c. Liquid temperature indicator.
  - d. Drain and filter valves.
  - e. Pressure relief device.

B. Dry-Type Distribution And Power Transformers

1. Description: NEMA ST 20, IEEE C57.12.01, ANSI C57.12.50 for dry-type transformers rated up to 500 kVA, ANSI C57.12.51 for dry-type transformers rated 501 kVA and larger, or ANSI C57.12.52 for sealed dry-type transformers rated 501 kVA and larger, UL 1562 listed and labeled, dry-type, 2-winding transformers.
  - a. Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, cast coil/encapsulated coil, with primary and secondary windings individually cast in epoxy; with insulation system rated at 185 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
  - b. Indoor, ventilated **OR** Outdoor, ventilated **OR** Totally enclosed, nonventilated, **as directed**, vacuum-pressure impregnated and with insulation system rated at 220 deg C with an 80 deg C average winding temperature rise above a maximum ambient temperature of 40 deg C.
2. Primary Connection: Air terminal compartment with removable **OR** hinged, **as directed**, door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.  
**OR**  
Primary Connection: Transition terminal compartment with connection pattern to match switchgear.
3. Secondary Connection: Air terminal compartment with removable **OR** hinged, **as directed**, door. Tin-plated copper bar for incoming line termination, predrilled to accept terminals for indicated conductors.  
**OR**  
Secondary Connection: Transition terminal compartment with connection pattern to match switchgear **OR** bus duct, **as directed**.
4. Insulation Materials: IEEE C57.12.01, rated at 220 deg C.
5. Insulation Temperature Rise: 80 **OR** 115 **OR** 150, **as directed**, deg C, maximum rise above 40 deg C.
6. Basic Impulse Level: 60 **OR** 75 **OR** 95 **OR** 110, **as directed**, kV.
7. Full-Capacity Voltage Taps: Four nominal 2.5 percent taps, 2 above and 2 below rated primary voltage.  
**OR**  
Full-Capacity Voltage Taps: Four nominal 2.5 percent taps below rated primary voltage.
8. Cooling System: Class AA, self-cooled **OR** AA/FA, self-cooled, and with forced-air-cooled rating **OR** AA/FFA, self-cooled, and with provisions for future forced-air-cooled rating, **as directed**, complying with IEEE C57.12.01.
  - a. Automatic forced-air cooling system controls, including thermal sensors, fans, control wiring, temperature controller with test switch, power panel with current-limiting fuses, indicating lights, alarm, and alarm silencing relay.
  - b. Include mounting provision for fans.
9. Sound level may not exceed sound levels listed in NEMA TR 1, without fans operating.
10. High-Temperature Alarm: Sensor at transformer with local audible and visual alarm and contacts for remote alarm.

C. Pad-Mounted, Liquid-Filled Transformers

1. Description: ANSI C57.12.13, ANSI C57.12.26 for pad-mounted transformers with dead-front, separable, insulated, high-voltage, load-break cable connectors, IEEE C57.12.00 IEEE C57.12.22 for pad-mounted transformers with live-front high-voltage bushings pad-mounted, 2-winding transformers. Stainless-steel tank base and cabinet, **OR** cabinet, and sills, **as directed**.
2. Insulating Liquid: Mineral oil, complying with ASTM D 3487, Type II, and tested according to ASTM D 117.  
**OR**  
Insulating Liquid: Less flammable, edible-seed-oil based, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

**OR**

Insulating Liquid: Less flammable, dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall be biodegradable and nontoxic.

**OR**

Insulating Liquid: Less flammable, silicone-based dielectric, and UL listed as complying with NFPA 70 requirements for fire point of not less than 300 deg C when tested according to ASTM D 92. Liquid shall have low toxicity and be nonhazardous.

3. Insulation Temperature Rise: 55 **OR** 65, **as directed**, deg C when operated at rated kVA output in a 40 deg C ambient temperature. Transformer shall be rated to operate at rated kilovolt ampere in an average ambient temperature of 30 deg C over 24 hours with a maximum ambient temperature of 40 deg C without loss of service life expectancy.
4. Basic Impulse Level: 30 **OR** 60 **OR** 95, **as directed**, kV.
5. Full-Capacity Voltage Taps: Four 2.5 percent taps, 2 above and 2 below rated high voltage; with externally operable tap changer for de-energized use and with position indicator and padlock hasp.
6. High-Voltage Switch: 200 **OR** 300 **OR** 400, **as directed**, A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for radial feed with 3-phase, 2-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.  
**OR**  
High-Voltage Switch: 200 **OR** 300 **OR** 400, **as directed**, A, make-and-latch rating of 10-kA RMS, symmetrical, arranged for loop feed with 3-phase, 4-position, gang-operated, load-break switch that is oil immersed in transformer tank with hook-stick operating handle in primary compartment.
7. Primary Fuses: 150-kV fuse assembly with fuses complying with IEEE C37.47. Rating of current-limiting fuses shall be 50-kA RMS at specified system voltage.
  - a. Current-limiting type in dry-fuse holder wells, mechanically interlocked with liquid-immersed switch in transformer tank to prevent disconnect under load.
  - b. Internal liquid-immersed cartridge fuses.
  - c. Bay-O-Net liquid-immersed fuses that are externally replaceable without opening transformer tank.
  - d. Bay-O-Net liquid-immersed fuses in series with liquid-immersed current-limiting fuses. Bay-O-Net fuses shall be externally replaceable without opening transformer tank.
  - e. Bay-O-Net liquid-immersed current-limiting fuses that are externally replaceable without opening transformer tank.
8. Surge Arresters: Distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment. Transformers shall have three arresters for radial-feed **OR** three arresters for loop-feed **OR** six arresters for loop-feed, **as directed**, circuits.
9. High-Voltage Terminations and Equipment: Live front with externally clamped porcelain bushings and cable connectors suitable for terminating primary cable.  
**OR**  
High-Voltage Terminations and Equipment: Dead front with universal-type bushing wells for dead-front bushing-well inserts, complying with IEEE 386 and including the following:
  - a. Bushing-Well Inserts: One for each high-voltage bushing well.
  - b. Surge Arresters: Dead-front, elbow-type, metal-oxide-varistor units.
  - c. Parking Stands: One for each high-voltage bushing well.
  - d. Portable Insulated Bushings: Arranged for parking insulated, high-voltage, load-break cable terminators; one for each primary feeder conductor terminating at transformer.
10. Accessories:
  - a. Drain Valve: 1 inch (25 mm), with sampling device.
  - b. Dial-type thermometer.
  - c. Liquid-level gage.
  - d. Pressure-vacuum gage.
  - e. Pressure Relief Device: Self-sealing with an indicator.
  - f. Mounting provisions for low-voltage current transformers.

- g. Mounting provisions for low-voltage potential transformers.
- h. Busway terminal connection at low-voltage compartment.
- i. Alarm contacts for gages and thermometer listed above.

D. Identification Devices

- 1. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification For Electrical Systems".

E. Source Quality Control

- 1. Factory Tests: Perform design and routine tests according to standards specified for components. Conduct transformer tests according to ANSI C57.12.50 for ventilated dry-type distribution transformers 1 to 500 kVA, single phase, and 15 to 500 kVA, 3 phase, with high voltage 601 to 34,500 V and low voltage 208Y/120 to 4160 V; ANSI C57.12.51 for ventilated dry-type power transformers 501 kVA and larger, 3 phase, with high voltage 601 to 34,500 V and low voltage 208Y/120 to 4160 V; IEEE C57.12.90 for liquid-filled transformers; and IEEE C57.12.91 for dry-type distribution and power transformers.
- 2. Factory Tests: Perform the following factory-certified tests on each transformer:
  - a. Resistance measurements of all windings on rated-voltage connection and on tap extreme connections.
  - b. Ratios on rated-voltage connection and on tap extreme connections.
  - c. Polarity and phase relation on rated-voltage connection.
  - d. No-load loss at rated voltage on rated-voltage connection.
  - e. Excitation current at rated voltage on rated-voltage connection.
  - f. Impedance and load loss at rated current on rated-voltage connection and on tap extreme connections.
  - g. Applied potential.
  - h. Induced potential.
  - i. Temperature Test: If transformer is supplied with auxiliary cooling equipment to provide more than one rating, test at lowest kilovolt-ampere Class OA or Class AA rating and highest kilovolt-ampere Class OA/FA or Class AA/FA rating.
    - 1) Temperature test is not required if record of temperature test on an essentially duplicate unit is available.

### 1.3 EXECUTION

A. Installation

- 1. Install transformers on concrete bases.
  - a. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at Project, and requirements in Division 26 Section "Hangers And Supports For Electrical Systems".
  - b. Construct concrete bases of dimensions indicated, but not less than **4 inches (100 mm)** larger in both directions than supported unit and **4 inches (100 mm)** high.
  - c. Use **3000-psi (20.7-MPa)**, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
  - d. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around full perimeter of base.
  - e. Install epoxy-coated anchor bolts, for supported equipment, that extend through concrete base and anchor into structural concrete floor.
  - f. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - g. Tack-weld or bolt transformers to channel-iron sills embedded in concrete bases. Install sills level and grout flush with floor or base.



2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
- B. Identification
  1. Identify field-installed wiring and components and provide warning signs as specified in Division 26 Section "Identification For Electrical Systems", **as directed**.
- C. Connections
  1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- D. Field Quality Control
  1. Perform the following field tests and inspections and prepare test reports:
    - a. After installing transformers but before primary is energized, verify that grounding system at substation is tested at specified value or less.
    - b. After installing transformers and after electrical circuitry has been energized, test for compliance with requirements.
    - c. Perform visual and mechanical inspection and electrical test stated in NETA ATS. Certify compliance with test parameters.
    - d. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  2. Remove and replace malfunctioning units and retest as specified above.
  3. Test Reports: Prepare written reports to record the following:
    - a. Test procedures used.
    - b. Test results that comply with requirements.
    - c. Test results that do not comply with requirements and corrective actions taken to achieve compliance with requirements.
- E. Follow-Up Service
  1. Voltage Monitoring and Adjusting: If requested by the Owner, perform the following voltage monitoring after Final Completion but not more than six months after Final Acceptance:
    - a. During a period of normal load cycles as evaluated by the Owner, perform seven days of three-phase voltage recording at secondary terminals of each transformer. Use voltmeters with calibration traceable to National Institute of Science and Technology standards and with a chart speed of not less than 1 inch (25 mm) per hour. Voltage unbalance greater than 1 percent between phases, or deviation of any phase voltage from nominal value by more than plus or minus 5 percent during test period, is unacceptable.
    - b. Corrective Actions: If test results are unacceptable, perform the following corrective actions, as appropriate:
      - 1) Adjust transformer taps.
      - 2) Prepare written request for voltage adjustment by electric utility.
    - c. Retests: After corrective actions have been performed, repeat monitoring until satisfactory results are obtained.
    - d. Report: Prepare written report covering monitoring and corrective actions performed.
  2. Infrared Scanning: Perform as specified in Division 26 Section "Medium-voltage Switchgear".

END OF SECTION 26 12 13 00

## SECTION 26 12 13 00a - LOW-VOLTAGE TRANSFORMERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for low-voltage transformers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:
  - a. Distribution transformers.
  - b. Buck-boost transformers.

#### C. Submittals

1. Product Data: For each product indicated.
2. Shop Drawings: Indicate dimensions and weights.
  - a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Field quality-control test reports.
5. Operation and maintenance data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

#### E. Delivery, Storage, And Handling

1. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

### 1.2 PRODUCTS

#### A. General Transformer Requirements

1. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.
2. Cores: Grain-oriented, non-aging silicon steel.
3. Coils: Continuous windings without splices except for taps.
  - a. Internal Coil Connections: Brazed or pressure type.
  - b. Coil Material: Aluminum **OR** Copper, **as directed**.

#### B. Distribution Transformers

1. Comply with NEMA ST 20, and list and label as complying with UL 1561.
2. Provide transformers that are constructed to withstand seismic forces specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Cores: One leg per phase.
4. Enclosure: Ventilated **OR** Totally enclosed, nonventilated, **as directed**, NEMA 250, Type 2.





- a. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
5. Enclosure: Ventilated **OR** Totally enclosed, nonventilated, **as directed**, NEMA 250, Type 3R **OR** Type 4X, stainless steel, **as directed**.
  - a. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.
6. Transformer Enclosure Finish: Comply with NEMA 250.
  - a. Finish Color: Gray **OR** ANSI 49 gray **OR** ANSI 61 gray, **as directed**.
7. Taps for Transformers Smaller Than 3 kVA: None **OR** One 5 percent tap above normal full capacity, **as directed**.
8. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity **OR** Two 5 percent taps below rated voltage, **as directed**.
9. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity **OR** Two 2.5 percent taps above and four 2.5 percent taps below normal full capacity, **as directed**.
10. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 **OR** 115 **OR** 80, **as directed**, deg C rise above 40 deg C ambient temperature.
11. Energy Efficiency for Transformers Rated 15 kVA and Larger:
  - a. Complying with NEMA TP 1, Class 1 efficiency levels.
  - b. Tested according to NEMA TP 2.
12. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.
  - a. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
  - b. Indicate value of K-factor on transformer nameplate.
13. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.
14. Wall Brackets: Manufacturer's standard brackets.
15. Fungus Proofing: Permanent fungicidal treatment for coil and core.
16. Low-Sound-Level Requirements: Minimum of 3 dBA less than NEMA ST 20 standard sound levels when factory tested according to IEEE C57.12.91.

#### C. Buck-Boost Transformers

1. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.
2. Enclosure: Ventilated, NEMA 250, Type 2.
  - a. Finish Color: Gray **OR** ANSI 49 gray **OR** ANSI 61 gray, **as directed**.

#### D. Identification Devices

1. Nameplates: Engraved, laminated-plastic or metal nameplate. Nameplates are specified in Division 26 Section "Identification For Electrical Systems".

### 1.3 EXECUTION

#### A. Installation

1. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.
  - a. Brace wall-mounting transformers as specified in Division 26 Section "Hangers And Supports For Electrical Systems".
2. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, **as directed**, and requirements in Division 26 Section "Hangers And Supports For Electrical Systems".

#### B. Field Quality Control

1. Perform tests and inspections.
  2. Tests and Inspections:
    - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
    - b. Infrared Scanning: Two months after Final Completion, perform an infrared scan of transformer connections.
      - 1) Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
      - 2) Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Final Completion.
      - 3) Prepare a certified report identifying transformer checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
- C. Adjusting
1. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.
  2. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.
  3. Output Settings Report: Prepare a written report recording output voltages and tap settings.
- D. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 12 13 00a

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Task	Specification	Specification Description
26 12 13 00	02 84 33 00	Overhead Electrical Distribution
26 12 16 00	26 12 13 00	Medium-Voltage Transformers
26 12 16 00	26 12 13 00a	Low-Voltage Transformers
26 12 19 00	26 12 13 00	Medium-Voltage Transformers
26 12 19 00	26 12 13 00a	Low-Voltage Transformers
26 13 16 00	26 11 13 00	Secondary Unit Substations
26 13 19 00	26 11 13 00	Secondary Unit Substations
26 13 29 00	26 11 13 00	Secondary Unit Substations
26 13 29 00	26 11 16 11	Switchgear
26 18 36 00	26 11 16 11	Switchgear
26 21 13 00	26 05 13 16	Conductors And Cables
26 21 13 00	26 05 13 16a	Undercarpet Cables
26 21 13 00	26 05 13 16b	Medium-Voltage Cables
26 21 13 00	02 84 33 00	Overhead Electrical Distribution
26 21 16 00	26 05 13 16	Conductors And Cables
26 21 16 00	26 05 13 16a	Undercarpet Cables
26 21 16 00	26 05 13 16b	Medium-Voltage Cables
26 22 13 00	26 12 13 00	Medium-Voltage Transformers
26 22 13 00	02 84 33 00	Overhead Electrical Distribution
26 22 13 00	26 12 13 00a	Low-Voltage Transformers

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## SECTION 26 24 13 00 - ELECTRICITY METERING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for electricity metering. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes equipment for electricity metering by utility company and electricity metering by the Owner.

#### C. Definitions

1. KY Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity that is based on a relay opening and closing in response to the rotation of the disk in the meter.
2. PC: Personal computer.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For electricity-metering equipment.
  - a. Wiring Diagrams: For power, signal, and control wiring. Identify terminals and wiring designations and color-codes to facilitate installation, operation, and maintenance. Indicate recommended types, wire sizes, and circuiting arrangements for field-installed wiring, and show circuit protection features.
3. Field quality-control reports.
4. Operation and Maintenance Data. Include the following:
  - a. Application and operating software documentation.
  - b. Software licenses.
  - c. Software service agreement.
  - d. Hard copies of manufacturer's operating specifications, design user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy Submittal.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

#### F. Delivery, Storage, And Handling

1. Receive, store, and handle modular meter center according to NECA 400.

#### G. Project Conditions

1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical service.
  - b. Do not proceed with interruption of electrical service without the Owner's written permission.

#### H. Coordination

1. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:



- a. Comply with requirements of utilities providing electrical power services.
- b. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

I. Software Service Agreement (May Not Be Allowed For Publicly Funded Projects)

1. Technical Support: Beginning with Final Completion, provide software support for two years.
2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
  - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade its computer equipment if necessary.

1.2 PRODUCTS

A. Equipment For Electricity Metering By Utility Company

1. Meters will be furnished by utility company.
  2. Current-Transformer Cabinets: Comply with requirements of electrical-power utility company.
  3. Meter Sockets: Comply with requirements of electrical-power utility company.
- OR**
4. Modular Meter Center: Factory-coordinated assembly of a main service terminal box with lugs only **OR** disconnect device, **as directed**, wireways, tenant meter socket modules, and tenant feeder circuit breakers arranged in adjacent vertical sections. Assembly shall be complete with interconnecting buses and other features as specified below.
    - a. Comply with requirements of utility company for meter center.
    - b. Housing: NEMA 250, Type 1 **OR** Type 3R, **as directed**, enclosure.
    - c. Minimum Short-Circuit Rating: 22,000 **OR** 42,000 **OR** 65,000 **OR** 100,000, **as directed**, A symmetrical at rated voltage.
    - d. Main Disconnect Device: Circuit breaker, series-combination rated for use with downstream feeder and branch circuit breakers.

**OR**

Main Disconnect Device: Fusible switch, series-combination rated by circuit-breaker manufacturer to protect downstream feeder and branch circuit breakers.
  - e. Tenant Feeder Circuit Breakers: Series-combination-rated molded-case units, rated to protect circuit breakers in downstream tenant and to house loadcenters and panelboards that have 10,000-A interrupting capacity.
    - 1) Identification: Complying with requirements in Division 26 Section "Identification For Electrical Systems" with legend identifying tenant's address.
    - 2) Physical Protection: Tamper resistant, with hasp for padlock.
  - f. Meter Socket: Rating coordinated with indicated tenant feeder circuit rating.
  - g. Surge Protection: For main disconnect device, comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".

B. Equipment For Electricity Metering By the Owner

1. General Requirements for the Owner's Meters:
  - a. Comply with UL 1244.
  - b. Meters used for billing shall have an accuracy of 0.2 **OR** 0.5 **OR** 1.0, **as directed**, percent of reading, complying with requirements in ANSI C12.20.
  - c. Meters shall be certified by California Type Evaluation Program, **as directed**, as complying with Title 4, California Code of Regulations, Article 2.2, **as directed**.
  - d. Enclosure: NEMA 250, Type 1 **OR** Type 3R, **as directed**, minimum, with hasp for padlocking or sealing.



- e. Identification: Comply with requirements in Division 26 Section "Identification For Electrical Systems".
  - f. Memory Backup: Self-contained to maintain memory throughout power outages of 72 hours, minimum.
  - g. Sensors: Current-sensing type, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
    - 1) Type: Split **OR** Split and solid, **as directed**, core.
  - h. Current-Transformer Cabinet: Listed or recommended by metering equipment manufacturer for use with sensors indicated.
  - i. Building Automation System (BAS) Interface: One digital KY pulse to a user-definable increment of energy measurement. Match signal to BAS input and arrange to convey the instantaneous, integrated, demand level measured by meter to provide data for processing and possible programmed demand control action by destination system.
2. Kilowatt-hour Meter: Electronic single **OR** three **OR** single- and three, **as directed**, -phase meters, measuring electricity used.
- a. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
  - b. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours and current kilowatt load. Retain accumulated kilowatt-hour in a nonvolatile memory, until reset.  
**OR**  
Display: Digital electromechanical counter, indicating accumulative kilowatt-hours.
3. Kilowatt-hour/Demand Meter: Electronic single **OR** three **OR** single- and three, **as directed**, -phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.
- a. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
  - b. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating accumulative kilowatt-hours, current time and date, current demand, and historic peak demand, and time and date of historic peak demand. Retain accumulated kilowatt-hour and historic peak demand in a nonvolatile memory, until reset.
4. Data Transmission Cable: Transmit KY pulse data over Class 1 control-circuit conductors in raceway. Comply with Division 26 Section "Control-voltage Electrical Power Cables".
5. Software: PC based, a product of meter manufacturer, suitable for calculation of utility cost allocation and billing, **as directed**.
- a. Utility Cost Allocation: Automatically import energy-usage records to allocate energy costs for the following:
    - 1) At least 15 departments.
    - 2) At least 30 tenants.
    - 3) At least five processes.
    - 4) At least five buildings.
  - b. Tenant or Activity Billing Software: Automatically import energy-usage records to automatically compute and prepare tenant bills **OR** activity demand and energy-use statements, **as directed**, based on metering of energy use and peak demand, **as directed**. Maintain separate directory for each tenant's historical billing information. Prepare summary reports in user-defined formats and time intervals.

### 1.3 EXECUTION

#### A. Installation

- 1. Comply with equipment installation requirements in NECA 1.
- 2. Install meters furnished by utility company. Install raceways and equipment according to utility company's written requirements. Provide empty conduits for metering leads and extend grounding connections as required by utility company.
- 3. Install modular meter center according to NECA 400 switchboard installation requirements.

**B. Identification**

1. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
  - a. Series Combination Warning Label: Self-adhesive type, with text as required by NFPA 70.
  - b. Equipment Identification Labels: Adhesive film labels with clear protective overlay. For residential meters, provide an additional card holder suitable for printed, weather-resistant card **OR** typewritten card, **as directed**, with occupant's name.

**C. Field Quality Control**

1. Perform tests and inspections.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
  - a. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
  - b. Turn off circuits supplied by metered feeder and secure them in off condition.
  - c. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
  - d. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.
3. Electricity metering will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.

END OF SECTION 26 24 13 00

## SECTION 26 24 13 00a - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for enclosed switches and circuit breakers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Fusible switches.
  - b. Nonfusible switches.
  - c. Receptacle switches.
  - d. Shunt trip switches.
  - e. Molded-case circuit breakers (MCCBs).
  - f. Molded-case switches.
  - g. Enclosures.

#### C. Definitions

1. NC: Normally closed.
2. NO: Normally open.
3. SPDT: Single pole, double throw.

#### D. Performance Requirements

1. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed**.

#### E. Submittals

1. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.
2. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
  - a. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
4. Field quality-control reports.
5. Operation and maintenance data.

#### F. Quality Assurance

1. Testing Agency Qualifications: Member company of or an NRTL **OR** one who meets the requirements necessary for certification, **as directed**.
  - a. Testing Agency's Field Supervisor: Currently certified by NETA **OR** one who meets the requirements necessary for certification, **as directed**, to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with NFPA 70.

#### G. Project Conditions



1. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
  - a. Ambient Temperature: Not less than **minus 22 deg F (minus 30 deg C)** and not exceeding **104 deg F (40 deg C)**.
  - b. Altitude: Not exceeding **6600 feet (2010 m)**.
2. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  - a. Notify the Owner no fewer than seven days in advance of proposed interruption of electric service.
  - b. Indicate method of providing temporary electric service.
  - c. Do not proceed with interruption of electric service without the Owner's written permission.
  - d. Comply with NFPA 70E.

## 1.2 PRODUCTS

### A. Fusible Switches

1. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge **OR** plug, **as directed**, fuse interiors to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
2. Type HD, Heavy Duty, Single Throw, 240 **OR** 600, **as directed**, -V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
3. Type HD, Heavy Duty, Six Pole, Single Throw, 240 **OR** 600, **as directed**, -V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
4. Type HD, Heavy Duty, Double Throw, 240 **OR** 600, **as directed**, -V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
5. Accessories:
  - a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
  - b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - c. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
  - d. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
  - e. Auxiliary Contact Kit: One **OR** Two, **as directed**, NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
  - f. Hookstick Handle: Allows use of a hookstick to operate the handle.
  - g. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, and conductor material.
  - h. Service-Rated Switches: Labeled for use as service equipment.
  - i. Accessory Control Power Voltage: Remote mounted and powered; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

### B. Nonfusible Switches

1. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

2. Type HD, Heavy Duty, Single Throw, 240 **OR** 600, **as directed**, -V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
  3. Type HD, Heavy Duty, Six Pole, Single Throw, 240 **OR** 600, **as directed**, -V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
  4. Type HD, Heavy Duty, Double Throw, 240 **OR** 600, **as directed**, -V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
  5. Accessories:
    - a. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
    - b. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
    - c. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
    - d. Auxiliary Contact Kit: One **OR** Two, **as directed**, NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
    - e. Hookstick Handle: Allows use of a hookstick to operate the handle.
    - f. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, and conductor material.
    - g. Accessory Control Power Voltage: Remote mounted and powered; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.
- C. Receptacle Switches
1. Type HD, Heavy-Duty, Single-Throw Fusible Switch: 240 **OR** 600, **as directed**, -V ac, 30 **OR** 60 **OR** 100, **as directed**, A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate specified **OR** indicated, **as directed**, fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
  2. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 240 **OR** 600, **as directed**, -V ac, 30 **OR** 60 **OR** 100, **as directed**, A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
  3. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
  4. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).
- D. Shunt Trip Switches
1. General Requirements: Comply with ASME A17.1, **as directed**, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.
  2. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
  3. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary fuses, with a control power transformer **OR** source, **as directed**, of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.
  4. Accessories:
    - a. Oiltight key switch for key-to-test function.
    - b. Oiltight red **OR** green **OR** white **OR** yellow, **as directed**, ON pilot light.
    - c. Isolated neutral lug; 100 **OR** 200, **as directed**, percent rating.
    - d. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
    - e. Form C alarm contacts that change state when switch is tripped.



- f. Three-pole, double-throw, fire-safety and alarm relay; 120-V ac **OR** 24-V dc, **as directed**, coil voltage.
- g. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

E. Molded-Case Circuit Breakers

1. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
2. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
4. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
  - a. Instantaneous trip.
  - b. Long- and short-time pickup levels.
  - c. Long- and short-time time adjustments.
  - d. Ground-fault pickup level, time delay, and  $I^2t$  response.
5. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
6. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
7. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
8. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
9. Features and Accessories:
  - a. Standard frame sizes, trip ratings, and number of poles.
  - b. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, trip ratings, and conductor material.
  - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
  - d. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered **OR** remote-mounted and powered, **as directed**, type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
  - e. Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system, specified in Division 26 Section "Electrical Power Monitoring And Control".
  - f. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
  - g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
  - h. Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
  - i. Alarm Switch: One NO **OR** NC, **as directed**, contact that operates only when circuit breaker has tripped.
  - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
  - k. Zone-Selective Interlocking: Integral with electronic **OR** ground-fault, **as directed**, trip unit; for interlocking ground-fault protection function.
  - l. Electrical Operator: Provide remote control for on, off, and reset operations.

- m. Accessory Control Power Voltage: Integrally mounted, self-powered **OR** Remote mounted and powered, **as directed**; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

F. Molded-Case Switches

1. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
2. Features and Accessories:
  - a. Standard frame sizes and number of poles.
  - b. Lugs: Mechanical **OR** Compression, **as directed**, type, suitable for number, size, trip ratings, and conductor material.
  - c. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
  - d. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
  - e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
  - f. Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
  - g. Alarm Switch: One NO **OR** NC, **as directed**, contact that operates only when switch has tripped.
  - h. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
  - i. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
  - j. Electrical Operator: Provide remote control for on, off, and reset operations.
  - k. Accessory Control Power Voltage: Integrally mounted, self-powered **OR** Remote mounted and powered, **as directed**; 24-V ac **OR** 120-V ac **OR** 208-V ac **OR** 240-V ac **OR** 6-V dc **OR** 12-V dc **OR** 24-V dc, **as directed**.

G. Enclosures

1. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
  - a. Indoor, Dry and Clean Locations: NEMA 250, Type 1.
  - b. Outdoor Locations: NEMA 250, Type 3R.
  - c. Kitchen **OR** Wash-Down, **as directed**, Areas: NEMA 250, Type 4X, stainless steel.
  - d. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4.
  - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
  - f. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7 **OR** Type 9, **as directed**.

1.3 EXECUTION

A. Installation

1. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
2. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
4. Install fuses in fusible devices.
5. Comply with NECA 1.





- B. Identification
1. Comply with requirements in Division 26 Section "Identification For Electrical Systems".
    - a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
    - b. Label each enclosure with engraved metal or laminated-plastic nameplate.
- C. Field Quality Control
1. Perform tests and inspections.
  2. Acceptance Testing Preparation:
    - a. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
    - b. Test continuity of each circuit.
  3. Tests and Inspections:
    - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
    - b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
    - c. Perform the following infrared scan tests and inspections and prepare reports:
      - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each enclosed switch and circuit breaker. Remove front panels so joints and connections are accessible to portable scanner.
      - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each enclosed switch and circuit breaker 11 months after date of Final Completion.
      - 3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
    - d. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
  4. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
  5. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Adjusting
1. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
  2. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".

END OF SECTION 26 24 13 00a

## SECTION 26 24 13 00b - SWITCHBOARDS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for switchboards. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Service and distribution switchboards rated 600 V and less.
  - b. Transient voltage suppression devices.
  - c. Disconnecting and overcurrent protective devices.
  - d. Instrumentation.
  - e. Control power.
  - f. Accessory components and features.
  - g. Identification.
  - h. Mimic bus.

#### C. Performance Requirements

1. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For each switchboard and related equipment.
  - a. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
  - b. Detail enclosure types for types other than NEMA 250, Type 1.
  - c. Detail bus configuration, current, and voltage ratings.
  - d. Detail short-circuit current rating of switchboards and overcurrent protective devices.
  - e. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
  - f. Detail utility company's metering provisions with indication of approval by utility company.
  - g. Include evidence of NRTL listing for series rating of installed devices.
  - h. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
  - i. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.
  - j. Include diagram and details of proposed mimic bus.
  - k. Include schematic and wiring diagrams for power, signal, and control wiring.
3. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
4. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
5. Field Quality-Control Reports.



6. Operation and maintenance data.

E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA PB 2.
3. Comply with NFPA 70.
4. Comply with UL 891.

F. Delivery, Storage, And Handling

1. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
2. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) **OR** connect factory-installed space heaters to temporary electrical service, **as directed**, to prevent condensation.
3. Handle and prepare switchboards for installation according to NECA 400 **OR** NEMA PB 2.1, **as directed**.

G. Project Conditions

1. Interruption of Existing Electric Service: Do not interrupt electric service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electric service according to requirements indicated:
  - a. Notify the Owner no fewer than seven days in advance of proposed interruption of electric service.
  - b. Indicate method of providing temporary electric service.
  - c. Do not proceed with interruption of electric service without the Owner's written permission.
  - d. Comply with NFPA 70E.

H. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within five years from date of Final Completion.

## 1.2 PRODUCTS

A. Manufactured Units

1. Front-Connected, Front-Accessible Switchboards:
  - a. Main Devices: Panel **OR** Fixed, individually, **as directed**, mounted.
  - b. Branch Devices: Panel mounted.
  - c. Sections front and rear aligned.
2. Front- and Side-Accessible Switchboards:
  - a. Main Devices: Fixed, individually mounted.
  - b. Branch Devices: Panel mounted.
  - c. Sections front and rear aligned.
3. Front- and Rear-Accessible Switchboards:
  - a. Main Devices: Fixed, individually **OR** Drawout, **as directed**, mounted.
  - b. Branch Devices: Panel **OR** Fixed, individually **OR** Panel and fixed, individually **OR** Fixed and individually compartmented **OR** Individually compartmented and drawout, **as directed**, mounted.
  - c. Sections front and rear **OR** rear, **as directed**, aligned.
4. Nominal System Voltage: 480Y/277 V **OR** 208Y/120 V, **as directed**.
5. Main-Bus Continuous: 5000 **OR** 4000 **OR** 3000 **OR** 2500 **OR** 2000 **OR** 1600 **OR** 1200, **as directed**, A.

6. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
7. Indoor Enclosures: Steel, NEMA 250, Type 1 **OR** Type 5, **as directed**.
8. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray **OR** custom color, **as directed**, finish over a rust-inhibiting primer on treated metal surface.
9. Outdoor Enclosures: Type 3R **OR** Type 3R, with interior-lighted walk-in aisle, **as directed**.
  - a. Finish: Factory-applied finish in manufacturer's standard **OR** custom, **as directed**, color; undersurfaces treated with corrosion-resistant undercoating.
  - b. Enclosure: Flat **OR** Downward, rearward sloping, **as directed**, roof; bolt-on rear covers **OR** rear hinged doors, **as directed**, for each section, with provisions for padlocking.
  - c. Doors: Personnel door at each end of aisle, minimum width of 30 inches (762 mm); opening outwards; with panic hardware and provisions for padlocking **OR** cylinder lock, **as directed**.
  - d. Accessories: Fluorescent lighting fixtures, ceiling mounted; wired to a three-way light switch at each end of aisle; ground-fault circuit interrupter (GFCI) duplex receptacle; emergency battery pack lighting fixture installed on wall of aisle midway between personnel doors.
  - e. Walk-in Aisle Heating and Ventilating:
    - 1) Factory-installed electric unit heater(s), wall or ceiling mounted, with integral thermostat and disconnect and with capacities to maintain switchboard interior temperature of 40 deg F (5 deg C) with outside design temperature of 104 deg F (40 deg C).
    - 2) Factory-installed exhaust fan with capacities to maintain switchboard interior temperature of 100 deg F (38 deg C) with outside design temperature of 23 deg F (minus 5 deg C).
    - 3) Ventilating openings complete with replaceable fiberglass air filters.
    - 4) Thermostat: Single stage; wired to control heat and exhaust fan.
  - f. Power for Space Heaters, Ventilation, Lighting, and Receptacle: Include a control-power transformer within the switchboard. Supply voltage shall be 120 **OR** 120/240 **OR** 120/208, **as directed**, -V ac.
  - g. Power for space heaters, ventilation, lighting, and receptacle provided by a remote source.
10. Barriers: Between adjacent switchboard sections.
11. Insulation and isolation for main bus of main section, **as directed**, and main and vertical buses of feeder sections.
12. Cubical Space Heaters: Factory-installed electric space heaters of sufficient wattage in each vertical section to maintain enclosure temperature above expected dew point.
  - a. Space-Heater Control: Thermostats to maintain temperature of each section above expected dew point **OR** Manual switching of branch-circuit protective device, **as directed**.
  - b. Space-Heater Power Source: Transformer, factory installed in switchboard **OR** 120-V external branch circuit, **as directed**.
13. Utility Metering Compartment: Fabricated, barrier compartment and section complying with utility company's requirements; hinged sealed door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.
14. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks, **as directed**.
15. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
16. Removable, Hinged Rear Doors and Compartment Covers: Secured by captive thumb screws **OR** standard bolts, **as directed**, for access to rear interior of switchboard.
17. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.



18. Pull Box on Top of Switchboard:
  - a. Adequate ventilation to maintain temperature in pull box within same limits as switchboard.
  - b. Set back from front to clear circuit-breaker removal mechanism.
  - c. Removable covers shall form top, front, and sides. Top covers at rear shall be easily removable for drilling and cutting.
  - d. Bottom shall be insulating, fire-resistive material with separate holes for cable drops into switchboard.
  - e. Cable supports shall be arranged to facilitate cabling and adequate to support cables indicated, including those for future installation.
19. Buses and Connections: Three phase, four wire unless otherwise indicated.
  - a. Phase- and Neutral-Bus Material: One of the following:
    - 1) Hard-drawn copper of 98 percent conductivity, silver-plated, **as directed**, with tin-plated aluminum or copper feeder circuit-breaker line connections.
    - 2) Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
    - 3) Hard-drawn copper of 98 percent conductivity, silver-plated, **as directed**, or tin-plated, high-strength, electrical-grade aluminum alloy.
  - b. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
  - c. Ground Bus: ~~1/4-by-2-inch-~~ (6-by-50-mm-) **OR** ~~1/4-by-1-inch-~~ (6-by-25-mm-) **OR** Minimum-size required by UL 891, **as directed**, hard-drawn copper of 98 percent conductivity, equipped with mechanical **OR** compression, **as directed**, connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
  - d. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
  - e. Neutral Buses: 50 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
  - f. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical **OR** compression, **as directed**, connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
  - g. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
20. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
21. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.
22. Fungus Proofing: Permanent fungicidal treatment for overcurrent protective devices and other components including instruments and instrument transformers.

B. Transient Voltage Suppression Devices

1. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, wired-in **OR** plug-in **OR** bolt-on, **as directed**, solid-state, parallel-connected, modular (with field-replaceable modules) **OR** non-modular, **as directed**, type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:
  - a. Fuses, rated at 200-kA interrupting capacity.
  - b. Fabrication using bolted compression lugs for internal wiring.
  - c. Integral disconnect switch.
  - d. Redundant suppression circuits.
  - e. Redundant replaceable modules.
  - f. Arrangement with wire connections to phase buses, neutral bus, and ground bus.

- g. LED indicator lights for power and protection status.
- h. Audible alarm, with silencing switch, to indicate when protection has failed.
- i. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
- j. Four **OR** Six, **as directed**, -digit, transient-event counter set to totalize transient surges.
- 2. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase **OR** 120 kA per mode/240 kA per phase **OR** 80 kA per mode/160 kA per phase, **as directed**.
- 3. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
- 4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 **OR** 208Y/120 **OR** 600Y/347, **as directed**, -V, three-phase, four-wire circuits shall be as follows:
  - a. Line to Neutral: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
  - b. Line to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
  - c. Neutral to Ground: 800 V for 480Y/277 **OR** 400 V for 208Y/120 **OR** 1200 V for 600Y/347, **as directed**.
- 5. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
  - a. Line to Neutral: 400 V, 800 V from high leg.
  - b. Line to Ground: 400 V.
  - c. Neutral to Ground: 400 V.
- 6. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
  - a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
  - b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- C. Disconnecting And Overcurrent Protective Devices
  - 1. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with series-connected rating **OR** interrupting capacity, **as directed**, to meet available fault currents.
    - a. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
    - b. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
    - c. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
      - 1) Instantaneous trip.
      - 2) Long- and short-time pickup levels.
      - 3) Long- and short-time time adjustments.
      - 4) Ground-fault pickup level, time delay, and  $I^2t$  response.
    - d. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
    - e. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker; trip activation on fuse opening or on opening of fuse compartment door.
    - f. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
    - g. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
    - h. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
      - 1) Standard frame sizes, trip ratings, and number of poles.
      - 2) Lugs: Mechanical **OR** Compression, **as directed**, style, suitable for number, size, trip ratings, and conductor material.



- 3) Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
  - 4) Ground-Fault Protection: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
  - 5) Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
  - 6) Communication Capability: Circuit-breaker-mounted **OR** Universal-mounted **OR** Integral **OR** Din-rail-mounted, **as directed**, communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring And Control".
  - 7) Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 55 **OR** 75, **as directed**, percent of rated voltage.
  - 8) Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
  - 9) Auxiliary Contacts: One SPDT switch **OR** Two SPDT switches, **as directed**, with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
  - 20) Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
2. Insulated-Case Circuit Breaker (ICCB): 80 **OR** 100, **as directed**, percent rated, sealed, insulated-case power circuit breaker with interrupting capacity rating to meet available fault current.
- a. Fixed **OR** Drawout, **as directed**, circuit-breaker mounting.
  - b. Two-step, stored-energy closing.
  - c. Standard **OR** Full, **as directed**, function, microprocessor-based trip units with interchangeable rating plug, trip indicators, and the following field-adjustable settings:
    - 1) Instantaneous trip.
    - 2) Long- and short-time time adjustments.
    - 3) Ground-fault pickup level, time delay, and  $I^2t$  response.
  - d. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
  - e. Remote trip indication and control.
  - f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring And Control".
  - g. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
  - h. Control Voltage: 40-V dc **OR** 125-V dc **OR** 250-V dc **OR** 120-V ac, **as directed**.
3. Bolted-Pressure Contact Switch: Operating mechanism uses rotary-mechanical-bolting action to produce and maintain high clamping pressure on the switch blade after it engages the stationary contacts.
- a. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
  - b. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
    - 1) Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
    - 2) Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
  - c. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
  - d. Service-Rated Switches: Labeled for use as service equipment.



- e. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
    - 1) Configuration: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    - 2) Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
    - 3) No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
    - 4) Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
  - f. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
  4. High-Pressure, Butt-Type Contact Switch: Operating mechanism uses butt-type contacts and a spring-charged mechanism to produce and maintain high-pressure contact when switch is closed.
    - a. Main-Contact Interrupting Capability: Minimum of 12 times the switch current rating.
    - b. Operating Mechanism: Manual handle operation to close switch; stores energy in mechanism for opening and closing.
      - 1) Electrical Trip: Operation of lever or push-button trip switch, or trip signal from ground-fault relay or remote-control device, causes switch to open.
      - 2) Mechanical Trip: Operation of mechanical lever, push button, or other device causes switch to open.
    - c. Auxiliary Switches: Factory installed, single pole, double throw, with leads connected to terminal block, and including one set more than quantity required for functional performance indicated.
    - d. Service-Rated Switches: Labeled for use as service equipment.
    - e. Ground-Fault Relay: Comply with UL 1053; self-powered type with mechanical ground-fault indicator, test function, tripping relay with internal memory, and three-phase current transformer/sensor.
      - 1) Configuration: Integrally mounted **OR** Remote-mounted, **as directed**, relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
      - 2) Internal Memory: Integrates the cumulative value of intermittent arcing ground-fault currents and uses the effect to initiate tripping.
      - 3) No-Trip Relay Test: Permits ground-fault simulation test without tripping switch.
      - 4) Test Control: Simulates ground fault to test relay and switch (or relay only if "no-trip" mode is selected).
    - f. Open-Fuse Trip Device: Arranged to trip switch open if a phase fuse opens.
  5. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
  6. Fuses are specified in Division 26 Section "Fuses".
- D. Instrumentation
1. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
    - a. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, single **OR** tapped **OR** double, **as directed**, secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
    - b. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; wound **OR** bushing **OR** bar or window, **as directed**, type; single **OR** double, **as directed**, secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
    - c. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
    - d. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

2. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
  - a. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
    - 1) Phase Currents, Each Phase: Plus or minus 1 percent.
    - 2) Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
    - 3) Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
    - 4) Megawatts: Plus or minus 2 percent.
    - 5) Megavars: Plus or minus 2 percent.
    - 6) Power Factor: Plus or minus 2 percent.
    - 7) Frequency: Plus or minus 0.5 percent.
    - 8) Accumulated Energy, Megawatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
    - 9) Megawatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
    - 10) Contact devices to operate remote impulse-totalizing demand meter.
  - b. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.
3. Ammeters, Voltmeters, and Power-Factor Meters: ANSI C39.1.
  - a. Meters: **4-inch (100-mm)** diameter or **6 inches (150 mm)** square, flush or semiflush, with antiparallax 250-degree scales and external zero adjustment.
  - b. Voltmeters: Cover an expanded-scale range of nominal voltage plus 10 percent.
4. Instrument Switches: Rotary type with off position.
  - a. Voltmeter Switches: Permit reading of all phase-to-phase voltages and, where a neutral is indicated, phase-to-neutral voltages.
  - b. Ammeter Switches: Permit reading of current in each phase and maintain current-transformer secondaries in a closed-circuit condition at all times.
5. Feeder Ammeters: **2-1/2-inch (64-mm)** minimum size with 90- or 120-degree scale. Meter and transfer device with off position, located on overcurrent device door for indicated feeder circuits only.
6. Watt-Hour Meters and Wattmeters:
  - a. Comply with ANSI C12.1.
  - b. Three-phase induction type with two stators, each with current and potential coil, rated 5 A, 120 V, 60 Hz.
  - c. Suitable for connection to three- and four-wire circuits.
  - d. Potential indicating lamps.
  - e. Adjustments for light and full load, phase balance, and power factor.
  - f. Four-dial clock register.
  - g. Integral demand indicator.
  - h. Contact devices to operate remote impulse-totalizing demand meter.
  - i. Ratchets to prevent reverse rotation.
  - j. Removable meter with drawout test plug.
  - k. Semiflush mounted case with matching cover.
  - l. Appropriate multiplier tag.
7. Impulse-Totalizing Demand Meter:
  - a. Comply with ANSI C12.1.
  - b. Suitable for use with switchboard watt-hour meter, including two-circuit totalizing relay.
  - c. Cyclometer.
  - d. Four-dial, totalizing kilowatt-hour register.
  - e. Positive chart drive mechanism.
  - f. Capillary pen holding a minimum of one month's ink supply.
  - g. Roll chart with minimum 31-day capacity; appropriate multiplier tag.
  - h. Capable of indicating and recording five **OR 15 OR 30, as directed**, -minute integrated demand of totalized system.

E. Control Power

1. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer **OR** 120-V ac, supplied from remote branch circuit, **as directed**.
2. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondaries connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.
3. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
4. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

F. Accessory Components And Features

1. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
2. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.
3. Portable Circuit-Breaker Lifting Device: Floor-supported, roller-based, elevating carriage arranged for movement of circuit breakers in and out of compartments for present and future circuit breakers.
4. Overhead Circuit-Breaker Lifting Device: Mounted at top front of switchboard, with hoist and lifting yokes matching each drawout circuit breaker.
5. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

G. Identification

1. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on a photoengraved nameplate.
  - a. Nameplate: At least **0.032-inch- (0.813-mm-)** thick anodized aluminum, located at eye level on front cover of the switchboard incoming service section.
2. Mimic Bus: Entire single-line switchboard bus work, as depicted on factory record drawing, on an engraved laminated-plastic (Gravoply) nameplate.
  - a. Nameplate: At least **0.0625-inch- (1.588 mm-)** thick laminated plastic (Gravoply), located at eye level on front cover of the switchboard incoming service section.
3. Mimic Bus: Continuously integrated mimic bus factory applied to front of switchboard. Arrange in single-line diagram format, using symbols and letter designations consistent with final mimic-bus diagram.
4. Coordinate mimic-bus segments with devices in switchboard sections to which they are applied. Produce a concise visual presentation of principal switchboard components and connections.
5. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
6. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

1.3 EXECUTION

A. Installation

1. Install switchboards and accessories according to NECA 400 **OR** NEMA PB 2.1, **as directed**.
2. Equipment Mounting: Install switchboards on concrete base, **4-inch (100-mm)** nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.

- b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
    - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    - d. Install anchor bolts to elevations required for proper attachment to switchboards.
  3. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
  4. Comply with mounting and anchoring requirements specified in Division 26 Section "Hangers And Supports For Electrical Systems".
  5. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
  6. Install filler plates in unused spaces of panel-mounted sections.
  7. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
    - a. Set field-adjustable switches and circuit-breaker trip ranges.
  8. Install spare-fuse cabinet.
  9. Comply with NECA 1.
- B. Connections
1. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies". Drawings indicate general arrangement of bus, fittings, and specialties.
  2. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays For Electrical Systems". Drawings indicate general arrangement of cable trays, fittings, and specialties.
- C. Identification
1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
  2. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
  3. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
- D. Field Quality Control
1. Acceptance Testing Preparation:
    - a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
    - b. Test continuity of each circuit.
  2. Tests and Inspections:
    - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
    - b. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
    - c. Perform the following infrared scan tests and inspections and prepare reports:
      - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front **OR** front and rear, **as directed**, panels so joints and connections are accessible to portable scanner.
      - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Final Completion.
      - 3) Instruments and Equipment:

- a) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - d. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- 3. Switchboard will be considered defective if it does not pass tests and inspections.
- 4. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- E. Adjusting
  - 1. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
  - 2. Set field-adjustable circuit-breaker trip ranges as indicated **OR** as specified in Division 26 Section "Overcurrent Protective Device Coordination Study", **as directed**.
- F. Protection
  - 1. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

END OF SECTION 26 24 13 00b

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Task	Specification	Specification Description
26 24 16 00	01 51 13 00	Panelboards

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## SECTION 26 24 19 00 - POWER DISTRIBUTION UNITS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for power distribution units. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes freestanding, prepackaged, power distribution units for transforming, conditioning, and distributing electrical power.

#### C. Definitions

1. TVSS: Transient voltage surge suppression.
2. UPS: Uninterrupted power supply.

#### D. Submittals

1. Product Data: For power distribution units.
2. Shop Drawings: Include dimensioned plans, sections, and elevations. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - a. Wiring Diagrams: Power, signal, and control wiring.
3. Manufacturer Seismic Qualification Certification: Submit certification that power distribution units, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems". Include the following:
4. Field quality-control test reports.
5. Operation and Maintenance Data: For power distribution units to include in emergency, operation, and maintenance manuals.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NFPA 70.

#### F. Delivery, Storage, And Handling

1. Deliver equipment in fully enclosed vehicles after specified environmental conditions have been permanently established in spaces where equipment is to be placed.
2. Store equipment in spaces with environments controlled within manufacturer's ambient temperature and humidity tolerances for non-operating equipment.

### 1.2 PRODUCTS

#### A. Manufactured Units

1. Description: Integrated and coordinated assembly of power-line-conditioning and distribution components packaged in a single cabinet or modular assembly of cabinets each with full-swivel casters mounted to bottom frame, **as directed**. Include the following components:
  - a. Input-power, circuit-breaker section.
  - b. Isolation transformer.
  - c. TVSS system.
  - d. Output panelboard(s).



- e. Alarm, monitoring, and control system.
  2. Provide units that are constructed to withstand seismic forces specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
  3. Unit Capacity Rating: Unit shall carry indicated rms kilovolt-ampere load continuously without exceeding rated insulation temperature for the following input voltage and load current:
    - a. Input Voltage: Within rated input-voltage tolerance band of unit.
    - b. Load Current: Minimum of 3.0 crest factor and 85 percent total harmonic distortion.
- B. Input-Power, Circuit-Breaker Section
1. Description: 3-pole, shunt-tripped, thermal-magnetic-type circuit breaker, rated for indicated interrupting capacity and 125 percent of input current of unit at 100 percent rated load.
    - a. Dual-Input Units:
      - 1) Two input circuit breakers arranged to provide transfer between two input-voltage sources.
      - 2) Controls and interfaces to allow both open- and closed-transition transfer between two input-voltage sources.
      - 3) Use a 120-V permissive signal from both upstream voltage sources to indicate acceptable conditions for closed-transition transfer.
      - 4) Open second circuit breaker automatically after closed-transition transfer is completed.
- C. Isolation Transformer Section
1. Description: Dry-type, electrostatically shielded, three-phase, common-core, convection-air-cooled isolation transformer.
    - a. Comply with UL 1561 including requirements for nonsinusoidal load-current-handling capability defined by designated K-factor, **as directed**.
    - b. Cores: Grain-oriented, non-aging silicon steel, one leg per phase.
    - c. Coil Material and Insulation: Copper windings with a 220 deg C insulation class.
    - d. Temperature Rise: Designed for 80 **OR** 115 **OR** 150, **as directed**, deg C rise above 40 deg C ambient.
    - e. Output Impedance: 3.5 plus or minus 0.5 percent.
    - f. Regulation: 2 to 4 percent maximum, at full-resistive load; 5 percent maximum, at rated nonlinear load.
    - g. Taps: 6 full-capacity compensation taps at 2.5 percent increments; 2 above and 4 below nominal voltage.
    - h. Full-Load Efficiency: Minimum 96 percent at rated nonlinear, **as directed**, load.
    - i. Magnetic-Field Strength External to Transformer Enclosure: Less than 0.1 gauss at 450 mm.
    - j. Audible Noise: Comply with NEMA ST 20.
    - k. Electrostatic Shielding: Independently shield each winding with a double-copper, electrostatic shield arranged to minimize interwinding capacitance.
      - 1) Coil leads and terminal trips shall be arranged to minimize capacitive coupling between input and output connections.
      - 2) Shield Terminal: Separate, and marked "Shield" for grounding connection.
      - 3) Capacitance: Limit capacitance between primary and secondary windings to a maximum of 33 picofarads over a frequency range of 20 Hz to 1 MHz.
      - 4) Common-Mode Noise Attenuation: 120 dB minimum, 0.5 to 1.5 kHz; minus 65 dB minimum, 1.5 to 100 kHz.
      - 5) Normal-Mode Noise Attenuation: Minus 52 dB minimum, 1.5 to 10 kHz.
    - l. Neutral Rating: 1.732 times the system full-load ampere rating.
- D. TVSS System
1. Description: Integrated TVSS system complying with Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits", to protect unit panelboard, and having the following features:

- a. Disconnect Device: Manual, three-pole, fused disconnect switch to de-energize TVSS system while permitting power distribution units to continue operation. Fuses are rated at 200-kA interrupting capacity.
  - b. Nonlinear Loading: System shall accommodate rated-load current with a minimum 3.0 crest factor and 85 percent total harmonic distortion.
- E. Output Panelboards
  - 1. Description: Panelboards complying with Division 26 Section "Panelboards", except for mounting provisions. Mount in front of power distribution units behind flush doors. Include the following features:
    - a. Construction: 42 pole, 240 V, 3 phase; capable of accepting branch circuit breakers rated to 100 A.
    - b. Panelboard Rating: 225 A, with main circuit breaker.
    - c. Panelboard Phase, Neutral and Ground Buses: Copper, with neutral bus at least 1.732 times the nominal phase bus rating.
    - d. Isolated Ground Bus: Copper, adequate for branch-circuit equipment ground conductors; insulated from supports.
    - e. Branch Circuit Breakers: Bolt **OR** Plug, **as directed**, on.
    - f. Cable Racks: Removable and arranged for supporting and routing cables for panelboard entrance.
    - g. Access Panels: Arranged so additional branch-circuit wiring can be installed and connected in the future.
- F. Power Distribution Unit Controls
  - 1. Include the following control features:
    - a. Emergency, power-off switch integral with power distribution unit.
    - b. Emergency, power-off input terminals for connection to remote power-off switch.
    - c. Over-under alarm shutdown with automatic unit disconnection for the following alarm conditions:
      - 1) High temperature.
      - 2) High and low input or output voltage.
      - 3) Phase loss.
      - 4) Ground fault.
      - 5) Reverse phase rotation.
    - d. Ground-fault protection with automatic system shutdown.
    - e. Alarm Contacts: Electrically isolated, Form C (one normally open and one normally closed), summary alarm; contact set shall change state if any monitored function goes into alarm mode.
    - f. Remote Power-Off Control: Control circuit with connection to shunt trip of power distribution unit main power circuit breaker and terminals for connection to one or more remote power-off, push-button stations.
- G. Monitoring, Status, And Alarm Annunciation
  - 1. Description: Microprocessor-based monitoring, status, and alarm annunciation panel mounted flush in front of power distribution unit to provide status display and failure-indicating interface for the following:
    - a. Power Monitoring:
      - 1) Input Voltage: Line to line, rms.
      - 2) Output Voltage: Line to line, rms.
      - 3) Output Voltage: Line to neutral, rms.
      - 4) Output current.
    - b. Status Indication: Unit on.
    - c. Alarm Annunciation:
      - 1) High temperature.
      - 2) High and low input voltage.
      - 3) High and low output voltage.

- 4) Phase loss.
  - 5) Ground fault.
  - 6) Frequency.
  - 7) Phase rotation.
  - 8) TVSS module failure.
- d. Audible Alarm and Silencing Switch: Alarm sounds when alarm indication occurs. Silencing switch shall silence audible alarm but leave visual indication active until failure or other alarm conditions are corrected.

H. Sound Level

1. General: Fully assembled products comply with minimum sound-level requirements in NEMA ST 20 for transformers of corresponding ratings when factory tested according to IEEE C57.12.91.
2. General: Fully assembled products have a minimum of 3 dB less than the maximum sound levels prescribed for transformers of corresponding ratings when factory tested according to IEEE C57.12.91.

I. Finishes

1. Manufacturer's standard finish over corrosion-resistant pretreatment and primer.

J. Source Quality Control

1. Factory Tests: Design and routine tests shall comply with referenced standards.
2. Factory Sound-Level Tests: Conduct sound-level tests on equipment. Comply with IEEE C57.12.91 and NEMA ST 20.

### 1.3 EXECUTION

A. Installation

1. Arrange power distribution units to provide adequate access to equipment and circulation of cooling air.
2. Anchor or restrain floor-mounting power distribution units according to manufacturer's written instructions, seismic codes applicable to Project, **as directed**, and requirements in Division 26 Section "Hangers And Supports For Electrical Systems".
3. Identify equipment and install warning signs according to Division 26 Section "Identification For Electrical Systems".

B. Connections

1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  - a. Separately Derived Systems: Make grounding connections to grounding electrodes as indicated; comply with NFPA 70.
2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

C. Field Quality Control

1. Perform tests and inspections and prepare test reports.
2. Tests and Inspections:
  - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification for circuit breakers, molded case; and for transformers, dry type, air cooled, low voltage, small. Certify compliance with test parameters.
  - b. Perform functional tests of power distribution units throughout their operating ranges. Test each monitoring, status, and alarm function.
  - c. Infrared Scanning: Two months after Final Completion, perform an infrared scan of conductor and bus connections.

- 1) Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
  - 2) Perform 2 follow-up infrared scans of transformers, one at 4 months and the other at 11 months after Final Completion.
  - 3) Prepare a certified report identifying connections checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
3. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.
- D. Adjusting
1. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
  2. Adjust power distribution units to provide optimum voltage to equipment served throughout normal operating cycle of loads served. Record input and output voltages and adjustment settings, and incorporate into test results.
- E. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION 26 24 19 00

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Task	Specification	Specification Description
26 24 19 00	01 22 16 00	No Specification Required
26 24 19 00	26 09 23 00b	Electrical Power Monitoring And Control
26 24 19 00	23 09 23 53	Enclosed Controllers
26 24 19 00	26 11 16 11	Switchgear
26 24 19 00	26 09 23 00c	Motor-Control Centers

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## SECTION 26 25 13 00 - ENCLOSED BUS ASSEMBLIES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for enclosed bus assemblies. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Feeder-bus assemblies.
  - b. Plug-in bus assemblies.
  - c. Bus plug-in devices.

#### C. Definitions

1. TVSS: Transient voltage surge suppressor.

#### D. Submittals

1. Shop Drawings: For each type of bus assembly **OR** bus assembly and plug-in device, **as directed**.
  - a. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
  - b. Show fittings, materials, fabrication, and installation methods for listed fire-stop barriers and weather barriers.
  - c. Indicate required clearances, method of field assembly, and location and size of each field connection.
  - d. Detail connections to switchgear, switchboards, transformers, and panelboards.
  - e. Wiring Diagrams: Power and signal **OR** and control, **OR** signal, and control, **as directed**, wiring.
  - f. Seismic-Restraint Details: Signed and sealed by a qualified professional engineer.
    - 1) Design Calculations: Calculate requirements for selecting seismic restraints.
    - 2) Detail fabrication, including anchorages and attachments to structure and to supported equipment.
2. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:
  - a. Vertical and horizontal enclosed bus-assembly runs, offsets, and transitions.
  - b. Clearances for access above and to the side of enclosed bus assemblies.
  - c. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
  - d. Support locations, type of support, and weight on each support.
3. Location of adjacent construction elements including light fixtures, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.
4. Product Certificates: For each type of enclosed bus assembly, signed by product manufacturer.
5. Manufacturer Seismic Qualification Certification: Submit certification that enclosed bus assemblies, plug-in devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems" Include the following:
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - 1) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."



- 2) The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
- b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
- c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
6. Qualification Data: For professional engineer and testing agency.
7. Field quality-control test reports.
8. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

#### E. Quality Assurance

1. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
  - a. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 1.3.
2. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
3. Source Limitations: Obtain enclosed bus assemblies and plug-in devices through one source from a single manufacturer.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. Comply with NEMA BU 1, "Busways."
6. Comply with NFPA 70.

#### F. Delivery, Storage, And Handling

1. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Proper Handling, Installation, Operation and Maintenance of Busway Rated 600 Volts or Less."

#### G. Project Conditions

1. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding **122 deg F (50 deg C) OR 140 deg F (60 deg C), as directed.**

#### H. Coordination

1. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
2. Coordinate size and location of concrete curbs around openings for vertical bus. Concrete, reinforcement, and formwork requirements are specified in Division 31.

## 1.2 PRODUCTS

#### A. Enclosed Bus Assemblies

1. Feeder-Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.
  - a. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for feeder-bus assemblies with reinforcement strong enough to withstand seismic forces

- defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems" when mounting provisions and attachments are anchored to building structure
- b. Voltage: 120/208 **OR** 240 **OR** 480 **OR** 277/480, **as directed**, V; 3 phase; 100 **OR** 200 **OR** percent neutral capacity, **as directed**.
  - c. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
  - d. Bus Materials: Current-carrying copper **OR** aluminum, **as directed**, conductors, fully insulated with Class 130C insulation except at joints; plated surface at joints.
  - e. Ground:
    - 1) 50 percent capacity integral with housing.
    - 2) 50 percent capacity internal bus bars of material matching bus material.
    - 3) 50 percent capacity isolated, internal bus bar of material matching bus material.
  - f. Enclosure: Steel with manufacturer's standard finish **OR** Aluminum with manufacturer's standard finish **OR** Weatherproof, steel or aluminum with manufacturer's standard finish, sealed seams, drains, and removable closures, **as directed**.
  - g. Fittings and Accessories: Manufacturer's standard.
  - h. Mounting: Arranged flat, edgewise, or vertically without derating.
2. Plug-in Bus Assemblies: NEMA BU 1, low-impedance bus assemblies in nonventilated housing; single-bolt joints; ratings as indicated.
- a. Seismic Fabrication Requirements: Fabricate mounting provisions and attachments for switchboards with reinforcement strong enough to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems" when mounting provisions and attachments are anchored to building structure.
  - b. Voltage: 120/208 **OR** 240 **OR** 480 **OR** 277/480, **as directed**, V; 3 phase; 100 **OR** 200 **OR** percent neutral capacity, **as directed**.
  - c. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
  - d. Bus Materials: Current-carrying copper **OR** aluminum, **as directed**, conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.
  - e. Ground:
    - 1) 50 percent capacity integral with housing.
    - 2) 50 percent capacity internal bus bar of material matching bus material.
    - 3) 50 percent capacity isolated, internal bus bar of material matching bus material.
  - f. Enclosure: Steel, with manufacturer's standard finish, plug-in openings **24 inches (610 mm)** o.c., and hinged covers over unused openings **OR** Aluminum, with manufacturer's standard finish, plug-in openings **24 inches (610 mm)** o.c., and hinged covers over unused openings, **as directed**.
  - g. Fittings and Accessories: Manufacturer's standard.
  - h. Mounting: Arranged flat, edgewise, or vertically without derating.
- B. Plug-In Devices
1. Fusible Switches: NEMA KS 1, heavy duty; with R-type rejection **OR** J-type **OR** L-type, **as directed**, fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. See Division 16 Section "Fuses" for fuses and fuse installation requirements.
  2. Molded-Case Circuit Breakers: NEMA AB 1; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position.
  3. TVSS: NEMA 250, Type 1 enclosure with NEMA KS 1, fusible, disconnect switch and external handle to isolate TVSS from busway. TVSS product and installation requirements are specified in Division 16 Section "Transient Voltage Suppression."
  4. Motor Controllers: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
    - a. Control Circuit: 120 V; obtained from integral control power transformer, **as directed**, with a control power transformer **OR** source, **as directed**, of enough capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.

- b. Combination Controller: Factory-assembled combination controller and disconnect switch with or without overcurrent protection as indicated.
  - 1) Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with R-type rejection **OR** J-type, **as directed**, fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by a nationally recognized testing laboratory (NRTL) acceptable to authorities having jurisdiction. See Division 26 Section "Fuses" for fuses and fuse installation requirements.  
**OR**  
Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.  
**OR**  
Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
- c. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic. Overload relays shall have heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
- d. Adjustable Overload Relay: Dipswitch selected for motor running overload protection with NEMA ICS 2, Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic, and selected to protect motor against voltage and current unbalance and single phasing. Adjustable overload relays shall have Class II ground-fault protection with start and run delays to prevent nuisance trip on starting.
- 5. Multispeed Motor Controllers: Match controller to motor type, application, and number of speeds; include the following accessories:
  - a. Compelling relay ensures motor starts only at low speed.
  - b. Accelerating relay ensures properly timed acceleration through speeds lower than that selected.
  - c. Decelerating relay ensures automatically timed deceleration through each speed.
- 6. Accessories: Hookstick operator, adjustable to maximum extension of **14 feet (4.3 m)**, **as directed**.

### 1.3 EXECUTION

#### A. Installation

- 1. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.
  - a. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
  - b. Design each fastener and support to carry **200 lb (90 kg)** or 4 times the weight of bus assembly, whichever is greater.
  - c. Support bus assembly to prevent twisting from eccentric loading.
  - d. Support bus assembly with not less than **3/8-inch (10-mm)** steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
  - e. Fasten supports securely to building structure according to Division 26 Section "Hangers And Supports For Electrical Systems".
- 2. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.
- 3. Construct rated fire-stop assemblies where bus assemblies penetrate fire-rated elements such as walls, floors, and ceilings. Seal around penetrations according to Division 07 Section "Penetration Firestopping".

4. Install weatherseal fittings and flanges where bus assemblies penetrate exterior elements such as walls or roofs. Seal around openings to make weathertight. See Division 07 Section "Joint Sealants" for materials and application.
  5. Install a concrete curb at least 4 inches (100 mm) high around bus-assembly floor penetrations.
  6. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.
  7. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.
  8. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.
- B. Connections
1. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  2. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
- C. Field Quality Control
1. Perform tests and inspections and prepare test reports.
  2. Tests and Inspections:
    - a. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  3. Remove and replace units that do not pass tests and inspections and retest as specified above.
  4. Infrared Scanning: Two months after Final Completion, perform an infrared scan of bus assembly including joints and plug-in units.
    - a. Use an infrared-scanning device designed to measure temperature or detect significant deviations from normal values. Provide documentation of device calibration.
    - b. Perform 2 follow-up infrared scans of bus assembly, one at 4 months and the other at 11 months after Final Completion.
    - c. Prepare a certified report identifying bus assembly checked and describing results of scanning. Include notation of deficiencies detected, remedial action taken, and scanning observations after remedial action.
  5. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.
- D. Adjusting
1. Set field-adjustable, circuit-breaker trip ranges and overload relay trip settings, **as directed**, as indicated.
- E. Cleaning
1. Vacuum dirt and debris; do not use compressed air to assist in cleaning.
- F. Protection
1. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION 26 25 13 00



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Task	Specification	Specification Description
26 25 16 00	26 25 13 00	Enclosed Bus Assemblies
26 27 13 00	02 84 33 00	Overhead Electrical Distribution
26 27 16 00	01 22 16 00	No Specification Required
26 27 16 00	26 05 33 16	Raceways And Boxes
26 27 16 00	26 09 23 00b	Electrical Power Monitoring And Control
26 27 16 00	26 09 23 00c	Motor-Control Centers
26 27 19 00	26 05 19 13	Underfloor Raceways For Electrical Systems
26 27 23 00	26 05 33 16a	Wiring Devices
26 27 26 00	01 22 16 00	No Specification Required
26 27 26 00	26 05 33 16	Raceways And Boxes
26 27 26 00	26 05 33 16a	Wiring Devices
26 27 26 00	26 09 23 00b	Electrical Power Monitoring And Control
26 27 26 00	23 09 23 53	Enclosed Controllers
26 27 33 00	26 24 19 00	Power Distribution Units
26 27 73 00	26 05 33 16a	Wiring Devices

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## SECTION 26 28 13 00 - FUSES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for fuses. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, panelboards, switchboards, enclosed controllers, and motor-control centers.
  - b. Plug fuses rated 125-V ac and less for use in plug-fuse-type enclosed switches, fuseholders, and panelboards.
  - c. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.
  - d. Spare-fuse cabinets.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Operation and maintenance data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NEMA FU 1 for cartridge fuses.
3. Comply with NFPA 70.
4. Comply with UL 248-11 for plug fuses.

#### E. Project Conditions

1. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C), apply manufacturer's ambient temperature adjustment factors to fuse ratings.

### 1.2 PRODUCTS

#### A. Cartridge Fuses

1. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

#### B. Plug Fuses

1. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

#### C. Plug-Fuse Adapters

1. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

#### D. Spare-Fuse Cabinet

1. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
  - a. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.



- b. Finish: Gray, baked enamel.
- c. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
- d. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

### 1.3 EXECUTION

#### A. Fuse Applications

- 1. Cartridge Fuses:
  - a. Service Entrance: Class L, fast acting **OR** Class L, time delay **OR** Class RK1, fast acting **OR** Class RK1, time delay **OR** Class J, fast acting **OR** Class J, time delay **OR** Class T, fast acting, **as directed**.
  - b. Feeders: Class L, fast acting **OR** Class L, time delay **OR** Class RK1, fast acting **OR** Class RK1, time delay **OR** Class RK5, fast acting **OR** Class RK5, time delay **OR** Class J, fast acting **OR** Class J, time delay, **as directed**.
  - c. Motor Branch Circuits: Class RK1 **OR** Class RK5, **as directed**, time delay.
  - d. Other Branch Circuits: Class RK1, time delay **OR** Class RK5, time delay **OR** Class J, fast acting **OR** Class J, time delay, **as directed**.
  - e. Control Circuits: Class CC, fast acting **OR** time delay, **as directed**.
- 2. Plug Fuses:
  - a. Motor Branch Circuits: Edison-base type, dual **OR** Edison-base type, single **OR** Type S, dual **OR** Type S, single, **as directed**, element time delay.
  - b. Other Branch Circuits: Edison-base type, single-element fast acting **OR** Edison-base type, dual-element time delay **OR** Edison-base type, single-element time delay **OR** Type S, dual-element time delay **OR** Type S, single-element time delay, **as directed**.

#### B. Installation

- 1. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- 2. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.
- 3. Install spare-fuse cabinet(s).

#### C. Identification

- 1. Install labels complying with requirements for identification specified in Division 26 Section "Identification For Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 28 13 00



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Task	Specification	Specification Description
26 28 13 00	26 11 16 11	Switchgear
26 28 16 13	01 51 13 00	Panelboards
26 29 13 13	01 22 16 00	No Specification Required
26 29 13 13	23 09 23 53	Enclosed Controllers

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## SECTION 26 29 23 00 - VARIABLE FREQUENCY CONTROLLERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for variable frequency controllers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes separately enclosed, pre-assembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

#### C. Definitions

1. BAS: Building automation system.
2. CE: Conformance Europeene (European Compliance).
3. CPT: Control power transformer.
4. EMI: Electromagnetic interference.
5. IGBT: Insulated-gate bipolar transistor.
6. LAN: Local area network.
7. LED: Light-emitting diode.
8. MCP: Motor-circuit protector.
9. NC: Normally closed.
10. NO: Normally open.
11. OCPD: Overcurrent protective device.
12. PCC: Point of common coupling.
13. PID: Control action, proportional plus integral plus derivative.
14. PWM: Pulse-width modulated.
15. RFI: Radio-frequency interference.
16. TDD: Total demand (harmonic current) distortion.
17. THD(V): Total harmonic voltage demand.
18. VFC: Variable-frequency motor controller.

#### D. Performance Requirements

1. Seismic Performance: VFCs shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories.
2. LEED Submittals:
  - a. Product Data for Credit EA 5: For continuous metering equipment for energy consumption.
3. Shop Drawings: For each VFC indicated. Include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
  - a. Show tabulations of installed devices, equipment features, and ratings. Include the following:
    - 1) Each installed unit's type and details.
    - 2) Factory-installed devices.



- 3) Enclosure types and details.
- 4) Nameplate legends.
- 5) Short-circuit current (withstand) rating of enclosed unit.
- 6) Features, characteristics, ratings, and factory settings of each VFC and installed devices.
- 7) Specified modifications.
- b. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.
4. Harmonic Analysis Study and Report: Comply with IEEE 399 and NETA Acceptance Testing Specification; identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible **OR** designated, **as directed**, operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC **OR** at the defined PCC, **as directed**, to specified levels.
5. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
6. Qualification Data: For qualified testing agency.
7. Seismic Qualification Certificates: For VFCs, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based, and their installation requirements.
8. Product Certificates: For each VFC, from manufacturer.
9. Source quality-control reports.
10. Field quality-control reports.
11. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals. Include the following:
  - a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and MCP trip settings.
  - b. Manufacturer's written instructions for setting field-adjustable overload relays.
  - c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
  - d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.
12. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
13. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.
- F. Quality Assurance
  1. Testing Agency Qualifications: Member company of NETA or an NRTL.
    - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
  2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  3. Comply with NFPA 70.
  4. IEEE Compliance: Fabricate and test VFC according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
- G. Delivery, Storage, And Handling

1. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside controllers and install temporary electric heating, with at least 250 W per controller **OR** connect factory-installed space heaters to temporary electrical service, **as directed**.

H. Project Conditions

1. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
  - a. Ambient Temperature: Not less than **14 deg F (minus 10 deg C)** and not exceeding **104 deg F (40 deg C)**.
  - b. Ambient Storage Temperature: Not less than minus **4 deg F (minus 20 deg C)** and not exceeding **140 deg F (60 deg C)**
  - c. Humidity: Less than 95 percent (noncondensing).
  - d. Altitude: Not exceeding **3300 feet (1005 m)**.
2. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
  - a. Notify Owner no fewer than two days in advance of proposed interruption of electrical systems.
  - b. Indicate method of providing temporary electrical service.
  - c. Do not proceed with interruption of electrical systems without Owner's written permission.
  - d. Comply with NFPA 70E.
3. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

I. Coordination

1. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:
  - a. Torque, speed, and horsepower requirements of the load.
  - b. Ratings and characteristics of supply circuit and required control sequence.
  - c. Ambient and environmental conditions of installation location.
2. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
3. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

J. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period: Five years from date of Final Completion.

1.2 PRODUCTS

A. Manufactured Units

1. General Requirements for VFCs: Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
2. Application: Constant torque and variable torque.
3. VFC Description: Variable-frequency power converter (rectifier, dc bus, and IGBT, PWM inverter) factory packaged in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
  - a. Units suitable for operation of NEMA MG 1, Design A and Design B motors as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."

- b. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
  - c. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- 4. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- 5. Output Rating: Three-phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range **OR** 66 Hz, with torque constant as speed changes, **as directed**; maximum voltage equals input voltage.
- 6. Unit Operating Requirements:
  - a. Input AC Voltage Tolerance: Plus 10 and minus 10 **OR** 15, **as directed**, percent of VFC input voltage rating.
  - b. Input AC Voltage Unbalance: Not exceeding 3 **OR** 5, **as directed**, percent.
  - c. Input Frequency Tolerance: Plus or minus 3 percent of VFC frequency rating.
  - d. Minimum Efficiency: 96 **OR** 97, **as directed**, percent at 60 Hz, full load.
  - e. Minimum Displacement Primary-Side Power Factor: 96 **OR** 98, **as directed**, percent under any load or speed condition.
  - f. Minimum Short-Circuit Current (Withstand) Rating: 10 **OR** 22 **OR** 65 **OR** 100, **as directed**, kA.
  - g. Ambient Temperature Rating: Not less than 14 deg F (minus 10 deg C) and not exceeding 104 deg F (40 deg C).
  - h. Ambient Storage Temperature Rating: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
  - i. Humidity Rating: Less than 95 percent (noncondensing).
  - j. Altitude Rating: Not exceeding 3300 feet (1005 m).
  - k. Vibration Withstand: Comply with IEC 60068-2-6.
  - l. Overload Capability: 1.1 **OR** 1.5, **as directed**, times the base load current for 60 seconds; minimum of 1.8 times the base load current for three seconds.
  - m. Starting Torque: Minimum 100 percent of rated torque from 3 to 60 Hz.
  - n. Speed Regulation: Plus or minus 5 **OR** 10, **as directed**, percent.
  - o. Output Carrier Frequency: Selectable; 0.5 to 15, **as directed**, kHz.
  - p. Stop Modes: Programmable; includes fast, free-wheel, and dc injection braking.
- 7. Inverter Logic: Microprocessor based, 16 **OR** 32, **as directed**, bit, isolated from all power circuits.
- 8. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
  - a. Signal: Electrical.
  - b. Signal: Pneumatic.
- 9. Internal Adjustability Capabilities:
  - a. Minimum Speed: 5 to 25 percent of maximum rpm.
  - b. Maximum Speed: 80 to 100 percent of maximum rpm.
  - c. Acceleration: 0.1 to 999.9 seconds.
  - d. Deceleration: 0.1 to 999.9 seconds.
  - e. Current Limit: 30 to minimum of 150 percent of maximum rating.
- 10. Self-Protection and Reliability Features:
  - a. Input transient protection by means of surge suppressors to provide three-phase protection against damage from supply voltage surges 10 percent or more above nominal line voltage.
  - b. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
  - c. Under- and overvoltage trips.
  - d. Inverter overcurrent trips.
  - e. VFC and Motor Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing

- VFC overtemperature and motor overload alarm and trip; settings selectable via the keypad; NRTL approved.
- f. Critical frequency rejection, with three selectable, adjustable deadbands.
  - g. Instantaneous line-to-line and line-to-ground overcurrent trips.
  - h. Loss-of-phase protection.
  - i. Reverse-phase protection.
  - j. Short-circuit protection.
  - k. Motor overtemperature fault.
11. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
  12. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
  13. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
  14. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
  15. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
  16. Integral Input Disconnecting Means and OCPD: NEMA AB 1, instantaneous-trip circuit breaker **OR** NEMA AB 1, molded-case switch, with power fuse block and current-limiting fuses **OR** NEMA AB 1, thermal-magnetic circuit breaker **OR** NEMA KS 1, nonfusible switch, with power fuse block and current-limiting fuses **OR** NEMA KS 1, fusible switch, **as directed**, with pad-lockable, door-mounted handle mechanism.
    - a. Disconnect Rating: Not less than 115 percent of VFC input current rating.
    - b. Disconnect Rating: Not less than 115 percent of NFPA 70 motor full-load current rating or VFC input current rating, whichever is larger.
    - c. Auxiliary Contacts: NO/NC, arranged to activate before switch blades open.
    - d. Auxiliary contacts "a" and "b" arranged to activate with circuit-breaker handle.
    - e. NC **OR** NO, **as directed**, alarm contact that operates only when circuit breaker has tripped.
- B. Controls And Indication
1. Status Lights: Door-mounted LED indicators displaying the following conditions:
    - a. Power on.
    - b. Run.
    - c. Overvoltage.
    - d. Line fault.
    - e. Overcurrent.
    - f. External fault.
  2. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
    - a. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
    - b. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
      - 1) Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
  3. Historical Logging Information and Displays:
    - a. Real-time clock with current time and date.
    - b. Running log of total power versus time.

- c. Total run time.
- d. Fault log, maintaining last four faults with time and date stamp for each.
- 4. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
  - a. Output frequency (Hz).
  - b. Motor speed (rpm).
  - c. Motor status (running, stop, fault).
  - d. Motor current (amperes).
  - e. Motor torque (percent).
  - f. Fault or alarming status (code).
  - g. PID feedback signal (percent).
  - h. DC-link voltage (V dc).
  - i. Set point frequency (Hz).
  - j. Motor output voltage (V ac).
- 5. Control Signal Interfaces:
  - a. Electric Input Signal Interface:
    - 1) A minimum of two programmable analog inputs: 0- to 10-V dc **OR** 4- to 20-mA dc **OR** Operator-selectable "x"- to "y"-mA dc, **as directed**.
    - 2) A minimum of six multifunction programmable digital inputs.
  - b. Pneumatic Input Signal Interface: **3 to 15 psig (20 to 104 kPa)**.
  - c. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
    - 1) 0- to 10-V dc.
    - 2) 4- to 20-mA dc.
    - 3) Potentiometer using up/down digital inputs.
    - 4) Fixed frequencies using digital inputs.
  - d. Output Signal Interface: A minimum of one programmable analog output signal(s) (0- to 10-V dc **OR** 4- to 20-mA dc **OR** operator-selectable "x"- to "y"-mA dc, **as directed**), which can be configured for any of the following:
    - 1) Output frequency (Hz).
    - 2) Output current (load).
    - 3) DC-link voltage (V dc).
    - 4) Motor torque (percent).
    - 5) Motor speed (rpm).
    - 6) Set point frequency (Hz).
  - e. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
    - 1) Motor running.
    - 2) Set point speed reached.
    - 3) Fault and warning indication (overtemperature or overcurrent).
    - 4) PID high- or low-speed limits reached.
- 6. PID Control Interface: Provides closed-loop set point, differential feedback control in response to dual feedback signals. Allows for closed-loop control of fans and pumps for pressure, flow, or temperature regulation.
  - a. Number of Loops: One **OR** Two, **as directed**.
- 7. BAS Interface: Factory-installed hardware and software to enable the BAS to monitor, control, and display VFC status and alarms and energy usage. Allows VFC to be used with an external system within a multidrop LAN configuration; settings retained within VFC's nonvolatile memory.
  - a. Network Communications Ports: Ethernet and RS-422/485.
  - b. Embedded BAS Protocols for Network Communications: ASHRAE 135 BACnet **OR** Echelon LonWorks **OR** Johnson Metasys N2 **OR** Modbus/Memobus **OR** Siemens System 600 APOGEE, **as directed**; protocols accessible via the communications ports.

### C. Line Conditioning And Filtering

1. Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD at input terminals of all **OR** indicated, **as directed**, VFCs to less than 5 **OR** 8, **as directed**, percent and THD(V) to 3 **OR** 5, **as directed**, percent.  
**OR**  
Input Line Conditioning: Based on the harmonic analysis study and report, provide input filtering, as required, to limit TDD and THD(V) at the defined PCC per IEEE 519.
  2. Output Filtering: **<Insert requirements>**.
  3. EMI/RFI Filtering: CE marked; certify compliance with IEC 61800-3 for Category C2.
- D. Bypass Systems
1. Bypass Operation: Safely transfers motor between power converter output and bypass circuit, manually, automatically, or both. Selector switches set modes and indicator lights indicate mode selected. Unit is capable of stable operation (starting, stopping, and running) with motor completely disconnected from power converter.
  2. Bypass Mode: Manual operation only; requires local operator selection at VFC. Transfer between power converter and bypass contactor and retransfer shall only be allowed with the motor at zero speed.  
**OR**  
Bypass Mode: Field-selectable automatic or manual, allows local and remote transfer between power converter and bypass contactor and retransfer, either via manual operator interface or automatic control system feedback.
  3. Bypass Controller: Two-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.
    - a. Bypass Contactor: Load-break, IEC **OR** NEMA **as directed**, -rated contactor.
    - b. Output Isolating Contactor: Non-load-break, IEC **OR** NEMA, **as directed**, -rated contactor.
    - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.**OR**  
 Bypass Controller: Three-contactor-style bypass allows motor operation via the power converter or the bypass controller; with input isolating switch and barrier arranged to isolate the power converter input and output and permit safe testing and troubleshooting of the power converter, both energized and de-energized, while motor is operating in bypass mode.
    - a. Bypass Contactor: Load-break, IEC **OR** NEMA, **as directed**, -rated contactor.
    - b. Input and Output Isolating Contactors: Non-load-break, IEC **OR** NEMA, **as directed**, -rated contactors.
    - c. Isolating Switch: Non-load-break switch arranged to isolate power converter and permit safe troubleshooting and testing of the power converter, both energized and de-energized, while motor is operating in bypass mode; pad-lockable, door-mounted handle mechanism.
  4. Bypass Contactor Configuration: Full-voltage (across-the-line) **OR** Reduced-voltage (autotransformer), **as directed**, type.
    - a. NORMAL/BYPASS selector switch.
    - b. HAND/OFF/AUTO selector switch.
    - c. NORMAL/TEST Selector Switch: Allows testing and adjusting of VFC while the motor is running in the bypass mode.
    - d. Contactor Coils: Pressure-encapsulated type with coil transient suppressors, **as directed**.
      - 1) Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
      - 2) Power Contacts: Totally enclosed, double break, and silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
    - e. Control Circuits: 120-V ac; obtained from integral CPT, with primary and secondary fuses, with CPT **OR** control power source, **as directed**, of sufficient capacity to operate all integral devices and remotely located pilot, indicating, and control devices.
      - 1) CPT Spare Capacity: 50 **OR** 100 **OR** 200, **as directed**, VA.



- f. Overload Relays: NEMA ICS 2.
- 1) Melting-Alloy Overload Relays:
    - a) Inverse-time-current characteristic.
    - b) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
    - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
  - 2) Bimetallic Overload Relays:
    - a) Inverse-time-current characteristic.
    - b) Class 10 **OR** Class 20 **OR** Class 30, **as directed**, tripping characteristic.
    - c) Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
    - d) Ambient compensated.
    - e) Automatic resetting.
  - 3) Solid-State Overload Relays:
    - a) Switch or dial selectable for motor-running overload protection.
    - b) Sensors in each phase.
    - c) Class 10 **OR** Class 20 **OR** Class 10/20 selectable, **as directed**, tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
    - d) Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.
    - e) Analog communication module.
  - 4) NC **OR** NO, **as directed**, isolated overload alarm contact.
  - 5) External overload reset push button.

E. Optional Features

1. Multiple-Motor Capability: VFC suitable for variable-speed service to multiple motors. Overload protection shuts down VFC and motors served by it, and generates fault indications, when overload protection activates.
  - a. Configure to allow two or more motors to operate simultaneously at the same speed; separate overload relay for each controlled motor.  
**OR**  
 Configure to allow two motors to operate separately; operator selectable via local or remote switch or contact closures; single overload relay for both motors; separate output magnetic contactors for each motor.  
**OR**  
 Configure to allow two motors to operate simultaneously and in a lead/lag mode, with one motor operated at variable speed via the power converter and the other at constant speed via the bypass controller; separate overload relay for each controlled motor.
2. Damper control circuit with end of travel feedback capability.
3. Sleep Function: Senses a minimal deviation of a feedback signal and stops the motor. On an increase in speed-command signal deviation, VFC resumes normal operation.
4. Motor Preheat Function: Preheats motor when idle to prevent moisture accumulation in the motor.
5. Firefighter's Override (Smoke Purge) Input: On a remote contact closure from the firefighter's control station **OR** smoke-control fan controller, **as directed**, this password-protected input:
  - a. Overrides all other local and external inputs (analog/digital, serial communication, and all keypad commands).
  - b. Forces VFC to operate motor, without any other run or speed command, at a field-adjustable, preset speed.  
**OR**  
 Forces VFC to transfer to Bypass Mode and operate motor at full speed.
  - c. Causes display of Override Mode on the VFC display.
  - d. Reset VFC to normal operation on removal of override signal automatically **OR** manually, **as directed**.

6. Remote Indicating Circuit Terminals: Mode selection, controller status, and controller fault.
7. Remote digital operator kit.
8. Communication Port: RS-232 port, USB 2.0 port, or equivalent connection capable of connecting a printer and a notebook computer.

F. Enclosures

1. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
  - a. Dry and Clean Indoor Locations: Type 1.
  - b. Outdoor Locations: Type 3R **OR** Type 4X, **as directed**.
  - c. Kitchen **OR** Wash-Down, **as directed**, Areas: Type 4X, stainless steel.
  - d. Other Wet or Damp Indoor Locations: Type 4.
  - e. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.
2. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."

G. Accessories

1. General Requirements for Control-Circuit and Pilot Devices: NEMA ICS 5; factory installed in VFC enclosure cover unless otherwise indicated.
  - a. Push Buttons, Pilot Lights, and Selector Switches: Heavy **OR** Standard, **as directed**, -duty, oiltight, **as directed**, type.
    - 1) Push Buttons: Covered **OR** Lockable **OR** Recessed **OR** Shielded **OR** Shrouded **OR** Unguarded, **as directed**, types; maintained **OR** momentary, **as directed**.
    - 2) Pilot Lights: Incandescent **OR** LED **OR** Neon **OR** Resistor **OR** Transformer, **as directed**, types; push to test.
    - 3) Selector Switches: Rotary type.
    - 4) Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
2. NC **OR** NO **OR** Reversible NC/NO, **as directed**, bypass contactor auxiliary contact(s).
3. Control Relays: Auxiliary and adjustable pneumatic **OR** solid-state, **as directed**, time-delay relays.
4. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
  - a. Current Transformers: Continuous current rating, basic impulse insulating level (BIL) rating, burden, and accuracy class suitable for connected circuitry. Comply with IEEE C57.13.
5. Supplemental Analog **OR** Digital, **as directed**, Meters:
  - a. Elapsed-time meter.
  - b. Kilowatt meter.
  - c. Kilowatt-hour meter.
6. Breather and drain assemblies, to maintain interior pressure and release condensation in NEMA 250, Type 4 **OR** Type 4X **OR** Type 12, **as directed**, enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
7. Space heaters, with NC auxiliary contacts, to mitigate condensation in NEMA 250, Type 3R **OR** Type 4X **OR** Type 12, **as directed**, enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.
8. Cooling Fan and Exhaust System: For NEMA 250, Type 1 **OR** Type 12, **as directed**; UL 508 component recognized: Supply fan, with composite **OR** stainless steel, **as directed**, intake and exhaust grills and filters, **as directed**; 120-V ac; obtained from integral CPT.
9. Sun shields installed on fronts, sides, and tops of enclosures installed outdoors and subject to direct and extended sun exposure.
10. Spare control-wiring terminal blocks; unwired **OR** wired, **as directed**.

H. Source Quality Control

1. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
  - a. Test each VFC while connected to its specified motor **OR** a motor that is comparable to that for which the VFC is rated, **as directed**.
  - b. Verification of Performance: Rate VFCs according to operation of functions and features specified.
2. VFCs will be considered defective if they do not pass tests and inspections.
3. Prepare test and inspection reports.

### 1.3 EXECUTION

#### A. Examination

1. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
2. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
3. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
4. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Harmonic Analysis Study

1. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible **OR** designated, **as directed**, operating scenarios, including recommendations for VFC input filtering to limit TDD and THD(V) at each VFC **OR** at the defined PCC, **as directed**, to specified levels.
2. Prepare a harmonic analysis study and report complying with IEEE 399 and NETA Acceptance Testing Specification.

#### C. Installation

1. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
2. Wall-Mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than **79 inches (2000 mm)** above finished floor unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Division 26 Section "Hangers And Supports For Electrical Systems".
3. Floor-Mounting Controllers: Install VFCs on **4-inch (100-mm)** nominal thickness concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
4. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than **79 inches (2000 mm)** above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
  - a. Curbs and roof penetrations are specified in Division 07 Section "Roof Accessories".
  - b. Structural-steel channels are specified in Division 26 Section "Hangers And Supports For Electrical Systems".

5. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
  6. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
  7. Install fuses in each fusible-switch VFC.
  8. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26 Section "Fuses".
  9. Install heaters in thermal-overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
  10. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
  11. Comply with NECA 1.
- D. Identification
1. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
    - a. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
    - b. Label each VFC with engraved nameplate.
    - c. Label each enclosure-mounted control and pilot device.
  2. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.
- E. Control Wiring Installation
1. Install wiring between VFCs and remote devices and facility's central-control system, **as directed**. Comply with requirements in Division 26 Section "Control-voltage Electrical Power Cables"
  2. Bundle, train, and support wiring in enclosures.
  3. Connect selector switches and other automatic control devices where applicable.
    - a. Connect selector switches to bypass only those manual- and automatic control devices that have no safety functions when switches are in manual-control position.
    - b. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.
- F. Field Quality Control
1. Perform tests and inspections.
  2. Acceptance Testing Preparation:
    - a. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
    - b. Test continuity of each circuit.
  3. Tests and Inspections:
    - a. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
    - b. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.
    - c. Test continuity of each circuit.
    - d. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Owner before starting the motor(s).
    - e. Test each motor for proper phase rotation.
    - f. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
    - g. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.



- h. Perform the following infrared (thermographic) scan tests and inspections and prepare reports:
        - 1) Initial Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
        - 2) Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Final Completion.
        - 3) Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
      - i. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
    - 4. VFCs will be considered defective if they do not pass tests and inspections.
    - 5. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.
  - G. Startup Service
    - 1. Perform startup service.
      - a. Complete installation and startup checks according to manufacturer's written instructions.
  - H. Adjusting
    - 1. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Final Completion.
    - 2. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
    - 3. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to six times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Owner before increasing settings.
    - 4. Set the taps on reduced-voltage autotransformer controllers.
    - 5. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study".
    - 6. Set field-adjustable pressure switches.
  - I. Protection
    - 1. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
    - 2. Replace VFCs whose interiors have been exposed to water or other liquids prior to Final Completion.
  - J. Demonstration
    - 1. Train Owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 26 29 23 00

Task	Specification	Specification Description
26 29 33 13	21 30 00 00a	Diesel-Drive, Centrifugal Fire Pumps
26 29 33 13	21 31 13 00	Pressure-Maintenance Pumps
26 29 33 13	21 31 13 00a	Controllers for Fire-Pump Drivers

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## SECTION 26 31 00 00 - PHOTOVOLTAIC ENERGY EQUIPMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for Photovoltaic Energy Equipment. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. PV laminates (cells laminated into rigid sheets, with connecting cables).
  - b. PV modules (laminates in mounting frames).
  - c. Charge controllers.
  - d. Inverters.
  - e. Mounting structures.

#### C. Definitions

1. CEC: California Energy Commission.
2. ETFE: Ethylene tetrafluoroethylene.
3. FEP: Fluorinated ethylene propylene.
4. IP Code: Required ingress protection to comply with IEC 60529.
5. MPPT: Maximum power point tracking.
6. PTC: USA standard conditions for PV.
7. PV: Photovoltaic.
8. STC: Standard Test Conditions defined in IEC 61215.

#### D. Action Submittals

1. Product Data: For each type of product.
  - a. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.
  - b. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Shop Drawings: For PV modules.
  - a. Include plans, elevations, sections, and mounting details.
  - b. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - c. Detail fabrication and assembly.
  - d. Include diagrams for power, signal, and control wiring.

#### E. Informational Submittals

1. Field quality-control reports.
2. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

#### F. Closeout Submittals

1. Operation and Maintenance Data: For PV modules to include in operation and maintenance manuals.

#### G. Warranty



1. Manufacturer's Special Materials and Workmanship Warranty: Manufacturer agrees to repair or replace components of PV modules that fail in materials or workmanship within specified warranty period.
  - a. Manufacturer's materials and workmanship warranties include, but are not limited to, the following:
    - 1) Faulty operation of PV modules.
  - b. Warranty Period: Two **OR** Five years from date of Final Completion.
2. Manufacturer's Special Minimum Power Output Warranty: Manufacturer agrees to repair or replace components of PV modules that fail to exhibit the minimum power output within specified warranty period. Special warranty, applying to modules only, applies to materials only, on a prorated basis, for period specified.
  - a. Manufacturer's minimum power output warranties include, but are not limited to, the following warranty periods, from date of Final Completion:
    - 1) Specified minimum power output to 80 percent or more, for a period of 25 years.

## 1.2 PRODUCTS

### A. Performance Requirements

1. NRTL (Nationally Recognized Testing Laboratory) Listing: Entire assembly shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for electrical and fire safety, Class A **OR** Class C, according to UL 1703.
2. FM approved for NFPA 70, Class 1, Division 2, Group C and Group D hazardous locations.

### B. System Description

1. Grid-Tied PV System:
  - a. Connected via a utility meter to the electrical utility.
  - b. An array of six modules to generate a total nominal 1000 rated W.
  - c. System Components:
    - 1) Cell materials.
    - 2) PV modules.
    - 3) Array frame.
    - 4) Charge controller.
    - 5) Inverter.
    - 6) Overcurrent protection/combiner box.
    - 7) Mounting structure.
    - 8) Utility meter.
2. Battery-Storage PV System:
  - a. Connected to a battery bank to provide electricity to Project.
  - b. An array of six modules to generate a total nominal 1000 rated W.
  - c. System Components:
    - 1) Cell materials.
    - 2) PV modules.
    - 3) Array frame.
    - 4) Charge controller.
    - 5) Inverter.
    - 6) Overcurrent protection/combiner box.
    - 7) Mounting structure.
    - 8) Battery charge controller(s).
    - 9) Batteries.
    - 10) Battery-storage structure.

### C. Manufactured Units

1. Cell Materials: Amorphous silicon (a-Si) **OR** Cell Materials: Copper indium (di)selenide (CIS) **OR** Cell Materials: Copper indium gallium (di)selenide (CIGS) **OR** Cadmium telluride (CdTe) **OR**

- Cadmium sulfide **OR** Polycrystalline (c-Si) **OR** Polycrystalline (Gallium arsenide (GaAs) **OR** Monocrystalline (c-Si) **OR** Monocrystalline (Gallium arsenide (GaAs)), **as directed**.
2. Module Construction:
    - a. Nominal Size: **32 inches (800 mm)** wide by **64 inches (1600 mm)** long.
    - b. Weight: **42.8 lb (19.4 kg)**.
  3. Insulating Substrate Film: Flexible **OR** Rigid, polyester **OR** polyimide, **as directed**.
  4. Conducting Substrate Film: Flexible **OR** Rigid **OR** fluoropolymer, ETFE **OR** FEP, **as directed**.
  5. Encapsulant: Ethyl vinyl acetate.
  6. Front Panel: Fully tempered glass.
  7. Front Panel: **0.125-inch- (3.2-mm-)** thick glass.
  8. Front Panel: Low iron glass.
  9. Front Panel: Antireflective coating glass.
  10. Front Panel: Laminating film.
  11. Front Panel: Laminating material.
  12. Backing Material: Tempered glass.
  13. Backing Material: **0.125-inch- (3.2-mm-)** thick glass; color **as directed**.
  14. Backing Material: Polyester film.
    - a. **Layers: as directed.**
    - b. Color: White **OR as directed**.
  15. Backing Material: PVC film.
    - a. **Layers: as directed.**
    - b. Color: White **OR as directed**.
  16. Bypass Diode Protection: Internal.
  17. Junction Box:
    - a. Size: **1.56 by 3.96 by 0.52 inch (39.6 by 100.6 by 13.2 mm)**.
    - b. Fully potted, vandal resistant.
    - c. IP Code: IP65 **OR** IP66 **OR** IP67, **as directed**.
    - d. Flammability Test: UL 1703.
  18. Output Cabling:
    - a. **0.158 inch (4 mm)**.
    - b. Quick, multiconnect, polarized connectors.
    - c. Two-Conductor Harness: No traditional return wire is needed from the end of a row back to the source combiner.
  19. Series Fuse Rating: **as directed**.
- D. Capacities And Characteristics
1. Minimum Electrical Characteristics:
    - a. Rated Open Circuit Voltage ( $V_{oc}$ ): **as directed**.
    - b. Maximum System Voltage: **as directed**.
    - c. Maximum Power at Voltage ( $V_{pm}$ ): **as directed**.
    - d. Short-Circuit Temperature Coefficient: **as directed**.
    - e. Rated Short-Circuit Current ( $I_{sc}$ ): **as directed**.
    - f. Maximum System: **as directed**.
    - g. Rated Operation Current ( $I_{mp}$ ): **as directed**.
    - h. Maximum Power at STC ( $P_{max}$ ): **as directed**.
  2. Additional Electrical Characteristics:
    - a. PTC Rating: **as directed**.
    - b. Peak Power per Unit Area: **as directed**.
    - c. Tolerance of  $P_{max}$ : **as directed**.
    - d. Minimum Peak Power: **as directed**.
    - e. Series Fuse Rating: **as directed**.
    - f. Module Efficiency: **as directed**.
    - g. Temperature Cycling Range: **as directed**.
    - h. Humidity, Freeze, Damp Heat Condition: **as directed**.
    - i. Wind Loading or Surface Pressure: **as directed**.
    - j. Maximum Distortion Angle: **as directed**.

- k. Hailstone Impact Withstand: **as directed.**
    - l. Series Fuse Rating: **as directed.**
  - 3. Normal Operating Temperature Characteristics (NOTC):
    - a. Temperature at Nominal Operating Cell Temperature: **as directed.**
    - b. Temperature Coefficient (NOTC  $P_{max}$ ): **as directed.**
    - c. Temperature Coefficient (NOTC  $V_{oc}$ ): **as directed.**
    - d. Temperature Coefficient (NOTC  $I_{sc}$ ): **as directed.**
    - e. Temperature Coefficient (NOTC  $V_{mp}$ ): **as directed.**
    - f. Temperature Coefficient (NOTC  $I_{mp}$ ): **as directed.**
- E. Module Framing
  - 1. PV laminates mounted in anodized extruded-aluminum frames.
    - a. Entire assembly UL listed for electrical and fire safety, Class A **OR** Class C, according to UL 1703, complying with IEC 61215.
    - b. Frame strength exceeding requirements of certifying agencies in subparagraph above.
    - c. Finish: Anodized aluminum.
      - 1) Alloy and temper recommended by framing manufacturer for strength, corrosion resistance, and application of required finish.
      - 2) Color: As indicated by manufacturer's designations.
    - d. Finish: High-performance organic finish.
      - 1) Fluoropolymer Two-Coat System: Manufacturer's standard two-coat, thermocured system consisting of specially formulated inhibitive primer and fluoropolymer color topcoat containing not less than 70 percent PVC resin by weight.
      - 2) Color: As indicated by manufacturer's designations.
    - e. Finish: Baked-enamel finish.
      - 1) Color: As indicated by manufacturer's designations.
- F. Array Construction
  - 1. Framing:
    - a. Material: Extruded aluminum **OR** Galvanized steel **OR** Coated steel, **as directed.**
    - b. Maximum System Weight: Less than **4 lb/sq. ft. (19.53 kg/sq. m).**
    - c. Minimum Distance to Connectors: **as directed.**
    - d. Raceway Cover Plates: Plastic **OR** Aluminum **OR** Galvanized steel, **as directed.**
  - 2. Flat-Roof Mounting:
    - a. No roof penetrations.
    - b. Self-ballasting.
    - c. Wind-tunnel tested to **110-mph (160-km/h)** wind.
    - d. Service Life: **25** years.
    - e. Freestanding system.
- G. Charge Controller
  - 1. Charge Controller Electrical Characteristics:
    - a. Output Current Rating: **as directed.**
    - b. Nominal Battery Voltage: **as directed.**
    - c. PV Maximum Open Circuit Voltage: **as directed.**
    - d. Equalization Voltage: **as directed.**
    - e. Voltage Step-Down Capability: **as directed.**
    - f. Power Conversion Efficiency: **as directed.**
  - 2. Charge controllers shall have the following:
    - a. Digital display.
    - b. Data logging.
    - c. Remote interface.
    - d. External sensors.
    - e. Temperature compensation.

H. Inverter

1. Control Type: Pulse width modulation control.
2. Control Type: Maximum power point tracker control.
3. Inverter Electrical Characteristics:
  - a. Maximum Recommended PV Input Power: **as directed**.
  - b. Maximum Voc: **as directed**.
  - c. PV Start Voltage: **as directed**.
  - d. MPPT Voltage Range: **as directed**.
  - e. Maximum Input Current: **as directed**.
  - f. Number of String Inputs: **as directed**.
  - g. Number of Independent MPPT Circuits: **as directed**.
  - h. Nominal Output Voltage: **as directed**.
  - i. CEC Rated Power: **as directed**.
  - j. Nominal Output Voltage: **as directed**.
  - k. Maximum Output Current: **as directed**.
  - l. Peak Efficiency: **as directed**.
  - m. CEC Weighted Efficiency: **as directed**.
  - n. CEC Night Tare Loss: **as directed**.
  - o. DC/AC Terminal Range (AWG): **as directed**.
  - p. NEMA 250 Enclosure Rating: **as directed**.
4. Operating Conditions:
  - a. Operating Ambient Temperatures: **Minus 4 to plus 122 deg F (20 to plus 50 deg C)**.
  - b. Storage Temperature: **Minus 40 to plus 122 deg F (minus 40 to plus 50 deg C)**.
  - c. Relative Humidity: 0 to 95 percent, noncondensing.
5. Charge controllers shall have the following:
  - a. Overcurrent protection.
  - b. Generator input breaker box.
  - c. Automatic transfer relay.
  - d. Digital display.
  - e. Transformer.
  - f. Disconnect switch.
  - g. Shunt controller.
  - h. Shunt regulator.
  - i. Surge overload protection.
6. Enclosure:
  - a. NEMA 250, Type 3R.
  - b. Enclosure Material: Galvanized steel **OR** Steel, **as directed**.
  - c. Cooling Methods:
    - 1) Fan convection cooling.
    - 2) Passive cooling.
  - d. Protective Functions:
    - 1) AC over/under voltage.
    - 2) AC over/under frequency.
    - 3) Ground over current.
    - 4) Overtemperature.
    - 5) AC and dc overcurrent.
    - 6) DC over voltage.
  - e. Standard liquid crystal display, four lines, 20 characters, with user display and on/off toggle switch.
  - f. Weight: **260 lb (118 kg)**.
  - g. Dimensions: **54 by 36 by 19 inches (137 by 91 by 48 cm)**.
7. Disconnects:
  - a. Low-voltage disconnect.
  - b. Low-voltage reconnect.
  - c. High-temperature disconnect.
  - d. High-temperature reconnect.



8. Regulatory Approvals:
  - a. IEEE 1547.1.
  - b. IEEE 1547.3.
  - c. UL 1741.
9. Characteristics:
  - a. Inverter Dimensions: **as directed**.
  - b. Inverter Weight: **as directed**.

I. System Overcurrent Protection

1. Combiner Box:
  - a. Fuses: **as directed**.
  - b. Circuit Breakers: **as directed**.

J. Mounting Structures

1. Roof Mount: Extruded aluminum, two **OR** four rails, **as directed**, tilt legs, and roof standoffs.
2. Pole Mount: Top **OR** Panel tops **OR** Side, **as directed**.
3. Tracking Mounts: One **OR** Two axis, **as directed**.

1.3 EXECUTION

A. Examination

1. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
2. Do not begin installation until mounting surfaces have been properly prepared.
3. If preparation of mounting surfaces is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.
4. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.
5. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.
6. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Field Quality Control

1. Perform tests and inspections **with the assistance of a factory-authorized service representative**.
2. PV module will be considered defective if it does not pass tests and inspections.
3. Prepare test and inspection reports.

END OF SECTION 26 31 00 00



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Task	Specification	Specification Description
26 31 00 00	01 22 16 00	No Specification Required

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## SECTION 26 32 13 13 - PACKAGED ENGINE GENERATORS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for packaged engine generators. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes packaged engine-generator sets for emergency **OR** standby, **as directed**, power supply with the following features:
  - a. Gas and Diesel engine.
  - b. Unit-mounted and Remote-mounting cooling system.
  - c. Unit-mounted and Remote-mounting control and monitoring.
  - d. Performance requirements for sensitive loads.
  - e. Load banks.
  - f. Outdoor enclosure.

#### C. Definitions

1. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
2. LP: Liquid petroleum.

#### D. Submittals

1. Product Data: For each type of packaged engine generator and accessory indicated.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Manufacturer Seismic Qualification Certification: Submit certification that day tank, engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Source quality-control test reports.
5. Field quality-control test reports.
6. Operation and maintenance data.
7. Warranty: Special warranty specified in this Section.

#### E. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Manufacturer Qualifications: A qualified manufacturer. Maintain, within **200 miles (321 km)** of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
4. Comply with ASME B15.1.
5. Comply with NFPA 37.
6. Comply with NFPA 70.
7. Comply with NFPA 99 for healthcare facilities.
8. Comply with NFPA 110 requirements for Level 1 **OR** 2, **as directed**, emergency power supply system.





9. Comply with UL 2200.
10. Engine Exhaust Emissions: Comply with applicable state and local government requirements.
11. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

F. Project Conditions

1. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
  - a. Ambient Temperature: 5 to 40 deg C **OR** Minus 15 to plus 40 deg C, **as directed**.
  - b. Relative Humidity: 0 to 95 percent for outdoor units.
  - c. Altitude: Sea level to **1000 feet (300 m)**.
2. Unusual Service Conditions: Engine-generator equipment and installation are required to operate under the following conditions:
  - a. High salt-dust content in the air due to sea-spray evaporation.

## 1.2 PRODUCTS

A. Engine-Generator Set

1. Factory-assembled and -tested, engine-generator set.
2. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.
  - a. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
3. Capacities and Characteristics:
  - a. Power Output Ratings: Nominal ratings as indicated, with capacity as required to operate as a unit as evidenced by records of prototype testing.
  - b. Output Connections: Three-phase, three **OR** four, **as directed**, wire.
  - c. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.
4. Generator-Set Performance:
  - a. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
  - b. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
  - c. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
  - d. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  - e. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
  - f. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
  - g. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
  - h. Start Time: Comply with NFPA 110, Type 10, system requirements.

5. Generator-Set Performance for Sensitive Loads:
  - a. Oversizing generator compared with the rated power output of the engine is permissible to meet specified performance.
    - 1) Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
  - b. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
  - c. Transient Voltage Performance: Not more than 10 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within 0.5 second.
  - d. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
  - e. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
  - f. Transient Frequency Performance: Less than 2-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within three seconds.
  - g. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
  - h. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
  - i. Excitation System: Performance shall be unaffected by voltage distortion caused by nonlinear load.
    - 1) Provide permanent magnet excitation for power source to voltage regulator.
  - j. Start Time: Comply with NFPA 110, Type 10, system requirements.

B. Engine

1. Fuel: Fuel oil, Grade DF-2 **OR** Natural gas with automatic LP-gas standby **OR** Natural gas, **as directed**.
2. Rated Engine Speed: 1800 rpm.
3. Maximum Piston Speed for Four-Cycle Engines: **2250 fpm (11.4 m/s)**.
4. Lubrication System: The following items are mounted on engine or skid:
  - a. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
  - b. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
  - c. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.
5. Engine Fuel System:
  - a. Main Fuel Pump For Diesel-Fueled Engine: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.
  - b. Relief-Bypass Valve For Diesel-Fueled Engine: Automatically regulates pressure in fuel line and returns excess fuel to source.
  - c. Dual Natural Gas with LP-Gas Backup (Vapor-Withdrawal) System:
    - 1) Carburetor.
    - 2) Secondary Gas Regulators: One for each fuel type.
    - 3) Fuel-Shutoff Solenoid Valves: One for each fuel source.
    - 4) Flexible Fuel Connectors: One for each fuel source.
6. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
7. Governor: Adjustable isochronous, with speed sensing.

8. Cooling System:
  - a. Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.
    - 1) Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
    - 2) Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
    - 3) Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
    - 4) Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
    - 5) Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
      - a) Rating: **50-psig (345-kPa)** maximum working pressure with coolant at **180 deg F (82 deg C)**, and noncollapsible under vacuum.
      - b) End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.
  - b. Closed loop, liquid cooled, with remote radiator and integral engine-driven coolant pump.
    - 1) Configuration: Vertical **OR** Horizontal, **as directed**, air discharge.
    - 2) Radiator Core Tubes: Aluminum **OR** Nonferrous-metal construction other than aluminum, **as directed**.
    - 3) Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
    - 4) Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
    - 5) Fan: Driven by multiple belts from engine shaft **OR** totally enclosed electric motor with sealed bearings, **as directed**.
    - 6) Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
    - 7) Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
9. Muffler/Silencer:
  - a. Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
    - 1) Minimum sound attenuation of 25 dB at 500 Hz.
    - 2) Sound level measured at a distance of **10 feet (3 m)** from exhaust discharge after installation is complete shall be 85 dBA or less.
  - b. Residential type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
    - 1) Minimum sound attenuation of 18 dB at 500 Hz.
    - 2) Sound level measured at a distance of **10 feet (3 m)** from exhaust discharge after installation is complete shall be 95 dBA or less.
  - c. Industrial type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.
    - 1) Minimum sound attenuation of 12 dB at 500 Hz.
    - 2) Sound level measured at a distance of **25 feet (8 m)** from exhaust discharge after installation is complete shall be 87 dBA or less.
10. Air-Intake Filter: Standard **OR** Heavy, **as directed**, duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.
11. Starting System: 12 **OR** 24, **as directed**, -V electric, with negative ground.

- a. Components: Sized so they will not be damaged during a full engine-cranking cycle with ambient temperature at maximum specified in Part 1 "Project Conditions" Article.
- b. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
- c. Cranking Cycle: As required by NFPA 110 for system level specified **OR** 60 seconds, **as directed**.
- d. Battery: Adequate capacity within ambient temperature range specified in Part 1.1 "Project Conditions" Article to provide specified cranking cycle at least twice **OR** three times, **as directed**, without recharging.
- e. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
- f. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg C regardless of external ambient temperature within range specified in Part 1.1 "Project Conditions" Article. Include accessories required to support and fasten batteries in place.
- g. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.
- h. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236.
  - 1) Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
  - 2) Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg C to plus 60 deg C to prevent overcharging at high temperatures and undercharging at low temperatures.
  - 3) Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
  - 4) Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
  - 5) Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
  - 6) Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet.

C. Fuel Oil Storage

1. Comply with NFPA 30.
2. Day Tank: Comply with UL 142, freestanding, factory-fabricated fuel tank assembly, with integral, float-controlled transfer pump and the following features:
  - a. Containment: Integral rupture basin with a capacity of 150 percent of nominal capacity of day tank.
    - 1) Leak Detector: Locate in rupture basin and connect to provide audible and visual alarm in the event of day-tank leak.
  - b. Tank Capacity: As recommended by engine manufacturer for an uninterrupted period of 4 hours' operation at 100 percent of rated power output of engine-generator system without being refilled.
  - c. Pump Capacity: Exceeds maximum flow of fuel drawn by engine-mounted fuel supply pump at 110 percent of rated capacity, including fuel returned from engine.
  - d. Low-Level Alarm Sensor: Liquid-level device operates alarm contacts at 25 percent of normal fuel level.
  - e. High-Level Alarm Sensor: Liquid-level device operates alarm and redundant fuel shutoff contacts at midpoint between overflow level and 100 percent of normal fuel level.

- f. Piping Connections: Factory-installed fuel supply and return lines from tank to engine; local fuel fill, vent line, overflow line; and tank drain line with shutoff valve.
- g. Redundant High-Level Fuel Shutoff: Actuated by high-level alarm sensor in day tank to operate a separate motor device that disconnects day-tank pump motor. Sensor shall signal solenoid valve, located in fuel suction line between fuel storage tank and day tank, to close. Both actions shall remain in shutoff state until manually reset. Shutoff action shall initiate an alarm signal to control panel but shall not shut down engine-generator set.
- 3. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:
  - a. Tank level indicator.
  - b. Capacity: Fuel for eight hours' continuous operation at 100 percent rated power output.
  - c. Vandal-resistant fill cap.
  - d. Containment Provisions: Comply with requirements of authorities having jurisdiction.

D. Control And Monitoring

- 1. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.
- 2. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.
- 3. Configuration:
  - a. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.
  - b. Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common wall-mounted control and monitoring panel.
  - c. Operating and safety indications, protective devices, basic system controls, engine gages, instrument transformers, generator disconnect switch or circuit breaker, and other indicated components shall be grouped in a combination control and power panel. Control and monitoring section of panel shall be isolated from power sections by steel barriers. Panel features shall include the following:
    - 1) Wall-Mounting Cabinet Construction: Rigid, self-supporting steel unit complying with NEMA ICS 6. Power bus shall be copper. Bus, bus supports, control wiring, and temperature rise shall comply with UL 891.
    - 2) Switchboard Construction: Freestanding unit complying with Division 26 Section "Switchboards".
    - 3) Switchgear Construction: Freestanding unit complying with Division 26 Section "Low-voltage Switchgear".
    - 4) Current and Potential Transformers: Instrument accuracy class.
- 4. Indicating and Protective Devices and Controls: As required by NFPA 110 for Level 1 **OR 2, as directed**, system, and the following:
  - a. AC voltmeter.
  - b. AC ammeter.
  - c. AC frequency meter.
  - d. DC voltmeter (alternator battery charging).
  - e. Engine-coolant temperature gage.
  - f. Engine lubricating-oil pressure gage.
  - g. Running-time meter.
  - h. Ammeter-voltmeter, phase-selector switch(es).

- i. Generator-voltage adjusting rheostat.
  - j. Fuel tank derangement alarm.
  - k. Fuel tank high-level shutdown of fuel supply alarm.
  - l. Generator overload.
5. Indicating and Protective Devices and Controls:
  - a. AC voltmeter.
  - b. AC ammeter.
  - c. AC frequency meter.
  - d. DC voltmeter (alternator battery charging).
  - e. Engine-coolant temperature gage.
  - f. Engine lubricating-oil pressure gage.
  - g. Running-time meter.
  - h. Ammeter-voltmeter, phase-selector switch(es).
  - i. Generator-voltage adjusting rheostat.
  - j. Start-stop switch.
  - k. Overspeed shutdown device.
  - l. Coolant high-temperature shutdown device.
  - m. Coolant low-level shutdown device.
  - n. Oil low-pressure shutdown device.
  - o. Fuel tank derangement alarm.
  - p. Fuel tank high-level shutdown of fuel supply alarm.
  - q. Generator overload.
6. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.
7. Connection to Data Link: A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication is reserved for connections for data-link transmission of indications to remote data terminals. Data system connections to terminals are covered in Division 26 Section "Electrical Power Monitoring And Control".
8. Common Remote Audible Alarm:
  - a. Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.
    - 1) Overcrank shutdown.
    - 2) Coolant low-temperature alarm.
    - 3) Control switch not in auto position.
    - 4) Battery-charger malfunction alarm.
    - 5) Battery low-voltage alarm.
  - b. Common Remote Audible Alarm for manually starting systems or for automatically starting systems not specified to comply with NFPA 110, Level 1, but where some remote alarm functions are needed. Signal the occurrence of any events listed below without differentiating between event types. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset.
    - 1) Engine high-temperature shutdown.
    - 2) Lube-oil, low-pressure shutdown.
    - 3) Overspeed shutdown.
    - 4) Remote emergency-stop shutdown.
    - 5) Engine high-temperature prealarm.
    - 6) Lube-oil, low-pressure prealarm.
    - 7) Fuel tank, low-fuel level.
    - 8) Low coolant level.
9. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.



10. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation.

E. Generator Overcurrent And Fault Protection

1. Generator Circuit Breaker:
  - a. Molded-case, thermal-magnetic type; 100 percent rated; complying with NEMA AB 1 and UL 489.
    - 1) Tripping Characteristic: Designed specifically for generator protection.
    - 2) Trip Rating: Matched to generator rating.
    - 3) Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
    - 4) Mounting: Adjacent to or integrated with control and monitoring panel.
  - b. Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.
    - 1) Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
    - 2) Trip Settings: Selected to coordinate with generator thermal damage curve.
    - 3) Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
    - 4) Mounting: Adjacent to or integrated with control and monitoring panel.
  - c. Insulated-case, electronic-trip type; 100 percent rated; complying with UL 489.
  - d. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
  - e. Trip Settings: Selected to coordinate with generator thermal damage curve.
  - f. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.
  - g. Mounting: Adjacent to or integrated with control and monitoring panel.
2. Generator Disconnect Switch: Molded-case type, 100 percent rated.
  - a. Rating: Matched to generator output rating.
  - b. Shunt Trip: Connected to trip switch when signaled by generator protector or by other protective devices.
3. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector shall perform the following functions:
  - a. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms.
  - b. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
  - c. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
  - d. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.
  - e. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

F. Generator, Exciter, And Voltage Regulator

1. Comply with NEMA MG 1.
2. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
3. Electrical Insulation: Class H or Class F.
4. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.



5. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.
6. Enclosure: Dripproof.
7. Instrument Transformers: Mounted within generator enclosure.
8. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.
  - a. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.
9. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.
10. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
11. Subtransient Reactance: 12 percent, maximum.

G. Load Bank

1. Description: Permanent, outdoor, weatherproof, remote-controlled, forced-air-cooled, resistive **OR** resistive and reactive, **as directed**, unit capable of providing a balanced 3-phase, delta-connected load to generator set at 100 percent rated-system capacity, at 80 percent power factor, lagging. Unit may be composed of separate resistive and reactive load banks controlled by a common control panel. Unit shall be capable of selective control of load in 25 percent steps and with minimum step changes of approximately 5 and 10 percent available.
2. Resistive Load Elements: Corrosion-resistant chromium alloy with ceramic and steel supports. Elements shall be double insulated and designed for repetitive on-off cycling. Elements shall be mounted in removable aluminized-steel heater cases.
3. Reactive Load Elements: Epoxy-encapsulated reactor coils.
4. Load-Bank Heat Dissipation: Integral fan with totally enclosed motor shall provide uniform cooling airflow through load elements. Airflow and coil operating current shall be such that, at maximum load, with ambient temperature at the upper end of specified range, load-bank elements operate at not more than 50 percent of maximum continuous temperature rating of resistance elements.
5. Load Element Switching: Remote-controlled contactors switch groups of load elements. Contactor coils are rated 120 V. Contactors shall be located in a separate NEMA 250, Type 3R enclosure within load-bank enclosure, accessible from exterior through hinged doors with tumbler locks.
6. Contactor Enclosures: Heated by thermostatically controlled strip heaters to prevent condensation.
7. Load-Bank Enclosures: NEMA 250, Type 3R, complying with NEMA ICS 6. Louvers at cooling-air intake and discharge openings shall prevent entry of rain and snow. Openings for airflow shall be screened with ~~1/2-inch-~~ (13-mm-) square, galvanized-steel mesh. Reactive load bank shall include automatic shutters at air intake and discharge.
8. Protective Devices: Power input circuits to load banks shall be fused, and fuses shall be selected to coordinate with generator circuit breaker. Fuse blocks shall be located in contactor enclosure. Cooling airflow and overtemperature sensors shall automatically shut down and lock out load bank until manually reset. Safety interlocks on access panels and doors shall disconnect load power, control, and heater circuits. Fan motor shall be separately protected by overload and short-circuit devices. Short-circuit devices shall be noninterchangeable fuses with 200,000-A interrupting capacity.
9. Remote-Control Panel: Separate from load bank in NEMA 250, Type 1 enclosure with a control power switch and pilot light, and switches controlling groups of load elements.
10. Control Sequence: Control panel may be preset for adjustable single-step loading of generator during automatic exercising.

H. Outdoor Generator-Set Enclosure

1. Description:
  - a. Vandal-resistant, weatherproof steel housing, wind resistant up to **100 mph (160 km/h)**. Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.



- b. Prefabricated or preengineered walk-in enclosure with the following features:
      - 1) Construction: Galvanized-steel, metal-clad, integral structural-steel-framed building erected on concrete foundation.
      - 2) Structural Design and Anchorage: Comply with ASCE 7 for wind loads.
      - 3) Space Heater: Thermostatically controlled and sized to prevent condensation.
      - 4) Louvers: Equipped with bird screen and filter arranged to permit air circulation when engine is not running while excluding exterior dust, birds, and rodents.
      - 5) Hinged Doors: With padlocking provisions.
      - 6) Ventilation: Louvers equipped with bird screen and filter arranged to permit air circulation while excluding exterior dust, birds, and rodents.
      - 7) Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine-generator-set components.
      - 8) Muffler Location: Within **OR** External to, **as directed**, enclosure.
  - 2. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.
    - a. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
    - b. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
  - 3. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.
    - a. AC lighting system and connection point for operation when remote source is available.
    - b. DC lighting system for operation when remote source and generator are both unavailable.
  - 4. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.
- I. Motors
  - 1. General requirements for motors are specified in Division 23 Section "Common Motor Requirements For Hvac Equipment".
    - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
    - b. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 22.
- J. Vibration Isolation Devices
  - 1. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.
    - a. Material: Standard neoprene **OR** Natural rubber **OR** Bridge-bearing neoprene, complying with AASHTO M 251, **as directed**.
    - b. Durometer Rating: 30 **OR** 40 **OR** 45 **OR** 50 **OR** 60 **OR** 65 **OR** 70, **as directed**.
    - c. Number of Layers: One **OR** Two **OR** Three **OR** Four, **as directed**.
  - 2. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.
    - a. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to **1/4-inch- (6-mm-)** thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
    - b. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
    - c. Minimum Additional Travel: 50 percent of required deflection at rated load.
    - d. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
    - e. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

K. Finishes

1. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

L. Source Quality Control

1. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.
  - a. Tests: Comply with NFPA 110, Level 1 Energy Converters and with IEEE 115.
  - b. Report factory test results within 10 days of completion of test.

1.3 EXECUTION

A. Installation

1. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
2. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.
3. Install packaged engine generator with elastomeric isolator pads **OR** restrained spring isolators, **as directed**, having a minimum deflection of **1 inch (25 mm)** on **4-inch- (100-mm-)** high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Install remote radiator with elastomeric isolator pads **OR** restrained spring isolators, **as directed**, having a minimum deflection of **1 inch (25 mm)** on concrete base on grade **OR** roof equipment supports on roof, **as directed**.
5. Install Schedule 40, black steel piping with welded joints for cooling water piping between engine-generator set and heat exchanger **OR** remote radiator, **as directed**. Piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping".
6. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping".
  - a. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 23 Section "Hydronic Piping".
7. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.
8. Piping installation requirements are specified in Division 21. Drawings indicate general arrangement of piping and specialties.
9. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.
10. Connect cooling-system water piping to engine-generator set and remote radiator **OR** heat exchanger, **as directed** with flexible connectors.
11. Connect engine exhaust pipe to engine with flexible connector.
12. Connect fuel piping to engines with a gate valve and union and flexible connector.
  - a. Natural-gas piping, valves, and specialties for gas distribution are specified in Division 23 Section "Facility Natural-gas Piping".
  - b. LP-gas piping, valves, and specialties for gas piping are specified in Division 23 Section "Facility Liquefied-petroleum Gas Piping".
13. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
14. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
15. Identify system components according to Division 23 Section "Identification For Hvac Piping And Equipment" and Division 26 Section "Identification For Electrical Systems".



## B. Field Quality Control

1. Perform tests and inspections and prepare test reports.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
  - a. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection (except those indicated to be optional) for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - b. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
  - c. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.
    - 1) Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    - 2) Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    - 3) Verify acceptance of charge for each element of the battery after discharge.
    - 4) Verify that measurements are within manufacturer's specifications.
  - d. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
  - e. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
  - f. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding **40-inch wg (120 kPa)**. Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
  - g. Exhaust Emissions Test: Comply with applicable government test criteria.
  - h. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
  - i. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
  - j. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.
3. Coordinate tests with tests for transfer switches and run them concurrently.
4. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
5. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
6. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
7. Remove and replace malfunctioning units and retest **OR** reinspect, **as directed**, as specified above.
8. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.
9. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

## C. Demonstration

1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain packaged engine generators.

END OF SECTION 26 32 13 13

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Task	Specification	Specification Description
26 32 13 19	26 32 13 13	Packaged Engine Generators
26 32 29 00	26 32 13 13	Packaged Engine Generators

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## SECTION 26 33 43 00 - CENTRAL BATTERY INVERTERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for central battery inverters. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes slow-transfer, fast-transfer, and UPS central battery inverters with the following features:
  - a. Output distribution section.
  - b. Internal maintenance bypass/isolation switch.
  - c. External maintenance bypass/isolation switch.
  - d. Multiple output voltages.
  - e. Emergency-only circuits.
  - f. Remote monitoring provisions.

#### C. Definitions

1. LCD: Liquid-crystal display.
2. LED: Light-emitting diode.
3. THD: Total harmonic distortion.
4. UPS: Uninterruptible power supply.

#### D. Submittals

1. Product Data: For the following:
  - a. Electrical ratings, including the following:
    - 1) Capacity to provide power during failure of normal ac.
    - 2) Inverter voltage regulation and THD of output current.
    - 3) Rectifier data.
    - 4) Transfer time of transfer switch.
    - 5) Data for specified optional features.
  - b. Transfer switch.
  - c. Inverter.
  - d. Battery charger.
  - e. Batteries.
  - f. Battery monitoring.
  - g. Battery-cycle warranty monitor.
2. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
  - a. Wiring Diagrams: Detail internal and interconnecting wiring; and power, signal, and control wiring.
  - b. Elevation and details of control and indication displays.
  - c. Output distribution section.
3. Manufacturer Seismic Qualification Certification: Submit certification that central battery inverter equipment will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Operation and Maintenance Data.

#### E. Quality Assurance





1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Central Battery Inverter System: UL 924 and UL 1778, **as directed**, listed.
3. Comply with NFPA 70 and NFPA 101.

F. Delivery, Storage, And Handling

1. Deliver equipment in fully enclosed vehicles.
2. Store equipment in spaces having environments controlled within manufacturers' written instructions for ambient temperature and humidity conditions for non-operating equipment.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty, applying to batteries only, applies to materials only, on a prorated basis, for period specified.
  - a. Warranty Period: Include the following warranty periods, from date of Final Completion:
    - 1) Premium, Valve-Regulated, Recombinant, Lead-Calcium Batteries:
      - a) Full Warranty: One year.
      - b) Pro Rata: 19 years.
    - 2) Standard, Valve-Regulated, Recombinant, Lead-Calcium Batteries:
      - a) Full Warranty: One year.
      - b) Pro Rata: Nine years.
    - 3) Nickel-Cadmium, Wet-Cell Batteries:
      - a) Full Warranty: Five years.
      - b) Pro Rata: 15 years.
    - 4) Lead-Calcium, Wet-Cell Batteries:
      - a) Full Warranty: One year.
      - b) Pro Rata: Nine years.
    - 5) Lead-Antimony, Wet-Cell Batteries:
      - a) Full Warranty: One year.
      - b) Pro Rata: Nine years.

## 1.2 PRODUCTS

A. Inverter Performance Requirements

1. Slow-Transfer Central Battery Inverters: Automatically sense loss of normal ac supply and use an electromechanical switch to transfer loads. Transfer in one second or less from normal supply to battery-inverter supply.
  - a. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.
2. Fast-Transfer Central Battery Inverters: Automatically sense loss of normal ac supply and use a solid-state switch to transfer loads. Transfer in 0.004 second or less from normal supply to battery-inverter supply.
  - a. Operation: Unit supplies power to output circuits from a single, external, normal supply source. Unit automatically transfers load from normal source to internal battery/inverter source. Retransfer to normal is automatic when normal power is restored.
3. UPS-Type Central Battery Inverters: Continuously provide ac power to connected electrical system.
  - a. Automatic Operation:
    - 1) Normal Conditions: Supply the load with ac power flowing from normal ac power input terminals, through rectifier-charger and inverter, with battery connected in parallel with rectifier-charger output.

- 2) Abnormal Supply Conditions: If normal ac supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, battery supplies constant, regulated, inverter ac power output to the load without switching or disturbance.
  - 3) If normal power fails, battery continues supply-regulated ac power through the inverter to the load without switching or disturbance.
  - 4) When power is restored at normal supply terminals of system, controls automatically synchronize inverter with the external source before transferring the load. Rectifier-charger then supplies power to the load through the inverter and simultaneously recharges battery.
  - 5) If battery becomes discharged and normal supply is available, rectifier-charger charges battery. When battery is fully charged, rectifier-charger automatically shifts to float-charge mode.
  - 6) If any element of central battery inverter system fails and power is available at normal supply terminals of system, static bypass transfer switch transfers the load to normal ac supply circuit without disturbance or interruption of supply.
  - 7) If a fault occurs in system supplied by central battery inverter and current flows in excess of the overload rating of central battery inverter system, static bypass transfer switch operates to bypass fault current to normal ac supply circuit for fault clearing.
  - 8) When fault has cleared, static bypass transfer switch returns the load to central battery inverter system.
  - 9) If battery is disconnected, central battery inverter continues to supply power to the load with no degradation of its regulation of voltage and frequency of output bus.
  - b. Manual Operation:
    - 1) Turning inverter off causes static bypass transfer switch to transfer the load directly to normal ac supply circuit without disturbance or interruption.
    - 2) Turning inverter on causes static bypass transfer switch to transfer the load to inverter.
  4. Maximum Acoustical Noise: **<Insert value>** dB, "A" weighting, emanating from any UPS component under any condition of normal operation, measured **39 inches (990 mm)** from nearest surface of component enclosure.
- B. Service Conditions
1. Environmental Conditions: Inverter system shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
    - a. Ambient Temperature for Electronic Components: **32 to 98 deg F (0 to 37 deg C)**.
    - b. Relative Humidity: 0 to 95 percent, noncondensing.
    - c. Altitude: Sea level to **4000 feet (1220 m)**.
- C. Inverters
1. Description: Solid-state type, with the following operational features:
    - a. Automatically regulate output voltage to within plus or minus 5 percent.
    - b. Automatically regulate output frequency to within plus or minus 1 Hz, from no load to full load at unit power factor over the operating range of battery voltage.
    - c. Output Voltage Waveform of Unit: Sine wave with maximum 10 percent THD throughout battery operating-voltage range, from no load to full load.
      - 1) THD may not exceed 5 percent when serving a resistive load of 100 percent of unit rating.
    - d. Output Protection: Current-limiting and short-circuit protection.  
**OR**  
Output Protection: Ferroresonant transformer to provide inherent overload and short-circuit protection.
    - e. Surge Protection: Panelboard **OR** Auxiliary panel, **as directed**, suppressors specified in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".



- f. Overload Capability: 125 percent for 10 minutes; 150 percent surge.
  - g. Brownout Protection: Produces rated power without draining batteries when input voltage is down to 75 percent of normal.
- D. Battery Charger
1. Description: Solid-state, automatically maintaining batteries in fully charged condition when normal power is available. With LED indicators for "float" and "high-charge" modes.
- E. Batteries
1. Description: Premium, valve-regulated, recombinant, lead-calcium **OR** Standard, valve-regulated, recombinant, lead-calcium **OR** Nickel-cadmium, wet-cell **OR** Lead-calcium, wet-cell **OR** Lead-antimony, wet-cell, **as directed**, batteries.
    - a. Capable of sustaining full-capacity output of inverter unit for minimum of 90 minutes.
- F. Enclosures
1. NEMA 250, Type 1 steel cabinets with access to components through hinged doors with flush tumbler lock and latch.
  2. Finish: Manufacturer's standard baked-enamel finish over corrosion-resistant prime treatment.
- G. Seismic Requirements
1. Central battery inverter assemblies, subassemblies, components, fastenings, supports, and mounting and anchorage devices shall be designed and fabricated to withstand seismic forces, **as directed**. The term "withstand" is defined in the "Manufacturer Seismic Qualification Certification" Paragraph in Part 1.1 "Submittals" Article.
- H. Control And Indication
1. Description: Group displays, indications, and basic system controls on common control panel on front of central battery inverter enclosure.
  2. Minimum displays, indicating devices, and controls shall include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms shall include an audible signal and a visual display.
  3. Indications: Labeled LED **OR** Plain-language messages on a digital LCD or LED, **as directed**.
    - a. Quantitative Indications:
      - 1) Input voltage, each phase, line to line.
      - 2) Input current, each phase, line to line.
      - 3) System output voltage, each phase, line to line.
      - 4) System output current, each phase.
      - 5) System output frequency.
      - 6) DC bus voltage.
      - 7) Battery current and direction (charge/discharge).
      - 8) Elapsed time-discharging battery.
    - b. Basic Status Condition Indications:
      - 1) Normal operation.
      - 2) Load-on bypass.
      - 3) Load-on battery.
      - 4) Inverter off.
      - 5) Alarm condition exists.
    - c. Alarm Indications:
      - 1) Battery system alarm.
      - 2) Control power failure.
      - 3) Fan failure.
      - 4) Overload.
      - 5) Battery-charging control faulty.
      - 6) Input overvoltage or undervoltage.
      - 7) Approaching end of battery operation.

- 8) Battery undervoltage shutdown.
- 9) Inverter fuse blown.
- 10) Inverter transformer overtemperature.
- 11) Inverter overtemperature.
- 12) Static bypass transfer switch overtemperature.
- 13) Inverter power supply fault.
- 14) Inverter output overvoltage or undervoltage.
- 15) System overload shutdown.
- 16) Inverter output contactor open.
- 17) Inverter current limit.
- d. Controls:
  - 1) Inverter on-off.
  - 2) Start.
  - 3) Battery test.
  - 4) Alarm silence/reset.
  - 5) Output-voltage adjustment.
4. Dry-form "C" contacts shall be available for remote indication of the following conditions:
  - a. Inverter on battery.
  - b. Inverter on-line.
  - c. Inverter load-on bypass.
  - d. Inverter in alarm condition.
  - e. Inverter off (maintenance bypass closed).
5. Include the following minimum array:
  - a. Ready, normal-power on light.
  - b. Charge light.
  - c. Inverter supply load light.
  - d. Battery voltmeter.
  - e. AC output voltmeter with minimum accuracy of 2 percent of full scale.
  - f. Load ammeter.
  - g. Test switch to simulate ac failure.
6. Enclosure: Steel, with hinged lockable doors, suitable for wall **OR** floor, **as directed**, mounting. Manufacturer's standard corrosion-resistant finish.
- I. Optional Features
  1. Multiple Output Voltages: Supply unit branch circuits at different voltage levels if required. Transform voltages internally as required to produce indicated output voltages.
  2. Emergency-Only Circuits: Automatically energize only when normal supply has failed. Disconnect emergency-only circuits when normal power is restored.
  3. Maintenance Bypass/Isolation Switch: Load is supplied, bypassing central battery inverter system. Normal supply, electromechanical transfer switch, and system load terminals are completely disconnected from external circuits.
  4. Maintenance Bypass/Isolation Switch: Switch is interlocked so it cannot be operated unless static bypass transfer switch is in bypass mode. Switch provides manual selection among the following three conditions without interrupting supply to the load during switching:
    - a. Full Isolation: Load is supplied, bypassing central battery inverter system. Normal ac input circuit, static bypass transfer switch, and central battery inverter load terminals are completely disconnected from external circuits.
    - b. Maintenance Bypass: Load is supplied, bypassing central battery inverter system. Central battery inverter ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
    - c. Normal: Normal central battery inverter ac supply terminals are energized and the load is supplied either through static bypass transfer switch and central battery inverter rectifier-charger and inverter or through battery and inverter.

J. Output Distribution Section



1. Panelboard: Comply with Division 26 Section "Panelboards" except provide assembly integral to equipment cabinet.

K. System Monitoring And Alarms

1. Remote Status and Alarm Panel: Labeled LEDs on panel faceplate shall indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
  - a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
2. Provisions for Remote Computer Monitoring: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in Part 1.2 "Control and Indication" Article. Remote computer and connecting signal wiring will be provided by the Owner. Include the following features:
  - a. Connectors and network interface units or modems for data transmission via RS-232 link.
  - b. Software shall be designed to control and monitor inverter system functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of reports. Include capability for storage and analysis of power-line transient records. Software shall be compatible with requirements in Division 26 Section "Electrical Power Monitoring And Control" and the operating system and configuration of the Owner-furnished computers.
3. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
  - a. Annunciation of Alarms: At inverter system control panel.
4. Battery-Cycle Warranty Monitoring: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring charge-discharge cycle history of batteries covered by cycle-life warranty.
  - a. Basic Functional Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on integral LCD.
  - b. Additional monitoring functions and features shall include the following:
    - 1) Measuring and recording of total voltage at battery terminals; providing alarm for excursions outside proper float voltage level.
    - 2) Monitoring of ambient temperature at battery and initiating an alarm if temperature deviates from normally acceptable range.
    - 3) Keypad on device front panel provides access to monitored data using front panel display.
    - 4) Alarm contacts arranged to provide local **OR** remote, **as directed**, alarm for battery discharge events **OR** abnormal temperature **OR** abnormal battery voltage or temperature, **as directed**.
    - 5) Memory device to store recorded data in nonvolatile electronic memory.
    - 6) RS-232 port to permit downloading of data to a portable personal computer.
    - 7) Modem to make measurements and recorded data accessible to remote personal computer via telephone line. Computer will be provided by the Owner.

L. Source Quality Control

1. Factory test complete inverter system, including battery, before shipment. Include the following:
  - a. Functional test and demonstration of all functions, controls, indicators, sensors, and protective devices.
  - b. Full-load test.
  - c. Transient-load response test.
  - d. Overload test.
  - e. Power failure test.
2. Observation of Test: Give 14 days' advance notice of tests and provide access for the Owner's representative to observe tests at the Owner's option.
3. Report test results. Include the following data:

- a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
- b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
- c. List of instruments and equipment used in factory tests.

### 1.3 EXECUTION

#### A. Installation

1. Install system components on floor **OR** concrete base, **as directed**, and attach by bolting.
  - a. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration And Seismic Controls For Electrical Systems" for seismic-restraint requirements.
  - b. Concrete Bases: **4 inches (100 mm)** high, reinforced, with chamfered edges. Extend base no more than **3 inches (75 mm)** in all directions beyond the maximum dimensions of switchgear unless otherwise indicated or unless required for seismic anchor support. Construct concrete bases according to Division 26 Section "Hangers And Supports For Electrical Systems".
  - c. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts according to anchor-bolt manufacturer's written instructions.
  - e. Use **3000-psi (20.7-MPa)**, 28-day compressive-strength concrete and reinforcement as specified in Division 03 Section "Cast-in-place Concrete".
2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.

#### B. Connections

1. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams, unless otherwise indicated.
2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
  - a. Separately Derived Systems: Make grounding connections to grounding electrodes and bonding connections to metallic piping systems as indicated; comply with NFPA 70.
3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### C. Identification

1. Identify equipment and components according to Division 26 Section "Identification For Electrical Systems".

#### D. Field Quality Control

1. Perform tests and inspections and prepare test reports.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
  - a. Inspect interiors of enclosures for integrity of mechanical and electrical connections, component type and labeling verification, and ratings of installed components.
  - b. Test manual and automatic operational features and system protective and alarm functions.
  - c. Test communication of status and alarms to remote monitoring equipment.
  - d. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specifications. Certify compliance with test parameters.



- e. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
3. Remove and replace malfunctioning units and retest as specified above.

E. Startup Service

1. Engage a factory-authorized service representative to perform startup service.
2. Verify that central battery inverter is installed and connected according to the Contract Documents.
3. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements in Division 22.
4. Complete installation and startup checks according to manufacturer's written instructions.

F. Adjusting And Cleaning

1. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
2. Install new filters in each equipment cabinet within 14 days from date of Final Completion.

END OF SECTION 26 33 43 00

## SECTION 26 33 43 00a - NURSE CALL

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for nurse call. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes visual/tone and audiovisual/voice nurse-call system.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment cabinets and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Cabling Diagrams: Single-line block diagrams showing cabling interconnection of all components for this specific equipment. Include cable type for each interconnection.
  - c. Station Installation Details: For built-in equipment, dimensioned and to scale.
3. Qualification Data: For qualified Installer.
4. Field quality-control reports.
5. Operation and Maintenance Data: For nurse-call equipment to include in emergency, operation, and maintenance manuals.
6. Warranty: Sample of special warranty.

#### D. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Compatibility: System shall be capable of integration with any brand of phone system (wired or wireless), staff locating system, CCTV, and fire-alarm system.
3. Electrical Components, Devices, and Accessories: Listed and labeled according to UL 1069 as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

#### E. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace batteries that fail in materials or workmanship within specified warranty period. Special warranty for batteries applies to materials only, on a prorated basis for specified period.
  - a. Warranty Period: Include the following warranty periods, from date of Final Completion:
    - 1) Nickel-Cadmium Batteries, Lithium Batteries, and Wet-Cell Batteries:
      - a) Full Warranty: Five years.
      - b) Pro Rata: 15 years.

### 1.2 PRODUCTS

#### A. Nurse-Call System General Requirements

1. Station Zones: Able to program 256 station zones for each master station in the network with eight priority levels and addressable visual and audible annunciation of audible devices such as smoke detectors and door contacts.
2. System shall provide integrated and centralized "Code Blue" and "Staff Emergency" calls.





3. Expansion Capability: Equipment ratings, housing volume, spare keys, switches, relays, annunciator modules, terminals, and cable conductor quantities adequate to increase the number of stations in the future by 25 percent above those indicated without adding internal or external components or main trunk cable conductors.
4. Existing System Compatibility: Functionally and electrically compatible with existing system so components and wiring operate as an extension or upgrade of the existing system and existing or upgraded functional performance of the existing system applies to the entire final system. Colors, tones, types, and durations of signal manifestation shall be common among new and existing systems.
5. Resistance to Electrostatic Discharge: System, components, and cabling, and the selection, arrangement, and connection of materials and circuits, shall be protected against damage or diminished performance when subjected to electrostatic discharges of up to 25,000 V in an environment with a relative humidity of 20 percent or less.
6. Equipment: Microprocessor, electronic, modular.
7. Master Nurse-Call Station: Programmed via a PC.
8. Wall-Mounted Component Connection Method: Components connect to system wiring in back boxes with factory-wired plug connectors.
9. Telephone Interface: Permit use of wired and wireless telephones to execute nurse-call master station functions.
10. Third-Party Pager Interface: Programmable to send tone, numeric, and alphanumeric message to pocket pagers or personal digital assistants and to use industry standard-protocol, RS-485 interface.

B. Visual/Tone Nurse-Call System

1. Operational Requirements:
  - a. Patient Station Call: Lights a steady call-placed lamp on the station, steady lamps in the zone light and corridor dome light associated with the patient's room, and steady lamps at the central annunciator and other system display devices and displays message on master and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the respective annunciator and master and staff/duty stations. Legends at the central annunciator and master station identify the calling station.
  - b. Pull-Cord-Call Station Call: Flashes a call-placed lamp on the station and distinctive-color lamps in the zone light and corridor dome light and at the central annunciator and staff/duty stations. At the same time, it sounds a programmed tone at intervals, at the central annunciator and master and staff/duty stations. A legend at the master station identifies the calling station, priority as programmed, and bed identification.
  - c. Emergency-Call Station Call: Produces the same responses as pull-cord-call station calls except rapidly flashing red emergency digital display and tone repetition rates are more frequent, tone frequency is higher, and lamps in the zone light and corridor dome light are a different color. Indicator lamps may be extinguished and the system reset only at the calling station. Displays message on pocket pagers, sounds programmed tone on phones, and displays message on display equipped phones.
  - d. System Reset: Operating reset button at the originating station cancels signals associated with the call. Illuminates a green digital display on the patient station and log presence on the master station.
  - e. Cord-Set Removal: Initiates a patient station call when the cord set is removed from the jack in the patient station faceplate. Displays location and "cord removed" message on master station, pocket pagers, and display equipped phones. Inserting a cord-set plug or a dummy plug into the jack and operating the station reset button resets the call.
  - f. Patient Control Unit: Controls entertainment volume and channel selection. Nurse button on the unit initiates a patient station call. Integral speaker reproduces entertainment sound.
  - g. Emergency Bath Station Call: Illuminates the digital display on the emergency bath station; rapidly flashes white dome lamp; displays location, priority, and bath on master

- station; and sounds programmed tone on master station display equipped phones and pocket pagers.
- h. Staff/Duty Station Operation: Operation shall be identified to patient station except the message staff shall display on all devices when the staff call button is activated.
  - i. Privacy Key Activation: When privacy key is activated on patient station, the system shall disconnect the patient station microphone and slowly flash yellow privacy digital display on the patient station. Displays "privacy" on master station when selecting this room/bed.
- 2. Central Annunciator:
    - a. Lamp type.
    - b. Lamp Legends: Machine lettered and legible from a distance of at least **48 inches (1200 mm)** when a call is present. Legend shall identify initiating station and priority of call.
    - c. Power-on Indicator: Digital, or push-to-test switch.
    - d. Audible Signal: Electronic tone.
  - 3. Central Equipment Cabinet:
    - a. Lockable metal.
    - b. Houses power supplies, controls, terminal strips, and other components.
    - c. Power-on indicator lamp.
    - d. Battery Backup Unit: Sealed nickel-cadmium, wet-cell battery supplies power through an automatic switch when normal power fails, for a period of not less than six minutes at rated output. System shall lose no unanswered calls or calls in progress during the transfer operation.
      - 1) Automatic retransfer to normal power, after a 15-minute time delay.
      - 2) Two-rate battery charger with an automatic trickle rate and a recharge rate.
  - 4. Single-Patient Station: Call-placed lamp, reset push button, and polarized receptacle matching cord-set plug; mounted in a single faceplate.
  - 5. Dual-Patient Station: Single call-placed lamp, single reset push button, and two polarized receptacles matching cord-set plug; mounted in a single faceplate.
  - 6. Ambulatory-Patient Station: Call push-button switch, call-placed lamp, and reset push button; mounted in a single faceplate.
  - 7. Staff/Duty Stations: A minimum of two call lamps, one for routine calls and one for emergency calls; and an audible tone signal device.
- C. Audiovisual/Voice Nurse-Call System
- 1. Operational Requirements:
    - a. Station Selection from Master Station: Capable of selectively communicating with other stations or groups of stations on its system by touch screen, mouse click, or manual switch; and capable of programming up to 256 stations for each master station in the network.
    - b. Master Station Privacy: Capable of conversing with individual stations in complete privacy.
    - c. Called Station:
      - 1) Capable of hands-free and two-way conversation.
      - 2) Pressing "talk/listen" key shall cause the annunciation tone to cease.
      - 3) Pressing "cancel" key terminates normal calls and conversations.
      - 4) Terminating of high-priority level 1 **OR 2 OR 3 OR 4, as directed**, shall not be allowed except at calling station location and shall send "remind" message if the call is not acknowledged at point of origin in programmed time frame.
    - d. Annunciation:
      - 1) At the master station, a programmable tone announces an incoming call; an annunciator light or digital display identifies the calling station and indicates the priority of the call.
      - 2) Call type indications include alarm assist, bath, bed, code, communication fault, cord out, door, emergency, and fire.
      - 3) Memory lamps or lighted displays identify stations selected for outgoing calls.
    - e. System Reset at Master Station: A normal, incoming call can be canceled, associated lights and audible tones extinguished, and the system reset when the station switch is returned to the normal position.



- f. Patient Station Calls:
  - 1) Lights the call-placed lamp at patient station, zone, and corridor dome lights.
  - 2) Sounds a tone and lights the call lights at staff/duty stations and actuates annunciation at the master station.
  - 3) When the calling station is selected at the master station, the patient can converse with the master station without moving and without raising or directing the voice.
  - 4) During voice communications, entertainment audio at the calling station is automatically muted.
- g. Pull-Cord-Call Station Calls and Emergency-Call Station Calls:
  - 1) Lights call-placed lamp and corridor dome light and flashes zone light.
  - 2) Master station tone pulses and annunciator light for that room flashes.
  - 3) When master station acknowledges the call by touch screen or switch, the tone stops but lights continue to flash until the call is canceled at the initiating point.
- h. Code Blue and Staff/Duty Station Calls:
  - 1) Lights the call-placed lamp at the station and actuates annunciation at the master station.
  - 2) When the called station is selected at the master station, the caller and the master station operator can converse.
  - 3) Code Blue: Unique sound and light pattern indicating the highest priority emergency.
  - 4) Staff Station: Unique sound and light pattern indicating an emergency.
  - 5) Duty Station: Sound and light pattern indicating a call to the nurse station.
- i. Handset Operation: Lifting the handset on master station disconnects speaker/microphone and transfers conversation to the handset.
- j. Station Privacy: No patient or staff/duty station can be remotely monitored without lighting a warning lamp at the monitored station.
- k. Patient Station Cord-Set Removal:
  - 1) A patient station call is initiated as described above when a patient station cord-set plug is removed from the jack in the station faceplate.
  - 2) Tone stops but lights continue to flash until the call is canceled at the initiating point or the plug is reinserted or replaced with a dummy plug when the master station call button for the station is pressed.
- l. Patient Control Unit:
  - 1) Controls entertainment volume and channel selection.
  - 2) Speaker is used for both nurse communication and entertainment sound.
  - 3) Entertainment sound is automatically muted when station is communicating with master station.
  - 4) Nurse button on the unit initiates a patient station call.
- m. Selective Paging: Master station is capable of initiating a message to selected groups of stations or speakers simultaneously by using station group switches.
- n. Staff Reminder:
  - 1) Master station can initiate a staff reminder that a patient requires direct staff response by operating a reminder control while in contact with the patient station.
  - 2) This reminder will light a distinctive-color lamp in the corridor dome light at the patient's room and in the appropriate zone lights.
  - 3) Reminder calls are canceled by operating a staff reminder cancel switch in the patient's room.
- o. Call Priority Indication:
  - 1) Capable of eight call priority levels in addition to normal.
  - 2) Call priority switch near each patient station, or integral with the master station, shall control priority status of the call transmitted by individual stations.
  - 3) Switch selects one of the following status levels:
    - a) Normal: No change to the normal call initiation and canceling sequence.

- b) Emergency: Call initiation produces signals and indications identical to those of emergency-call stations. Indicator lamps are extinguished and the system is reset only at the originating station.
- c) Priority: System response is the same for emergency status except voice communication between the master station and the calling station is locked in from the time of call initiation until the system is reset at the originating station.
- p. Additional Call:
  - 1) Waiting display window on the master station similar to current call window displays incoming calls.
  - 2) Master station shall have a call-overflow indicator when incoming calls exceed **<Insert number>** calls.
  - 3) System shall store unlimited number of incoming calls.
  - 4) System shall be capable of automatically answering incoming calls in order of priority.
- q. Calling Intercom Stations:
  - 1) Master station shall be capable of calling any intercom station using the handset or the hands-free speaker/microphone.
  - 2) Receipt of a call at the intercom station shall be preceded by an optional pre-announce tone.
  - 3) If there is a call in process, system shall place the active call on automatic hold while the new call is placed, then reestablish the previous call when the new call has ended.
- r. Privacy Override:
  - 1) Temporarily deactivates the "Privacy" mode of a called station by calling the station and instructing the called party to press the call-cord button.
  - 2) On completion of the conversation, the called station shall automatically return to the "Privacy" mode.
  - 3) When in "Privacy" mode, a called station shall be capable of hearing the master station; however, the master station shall not be capable of hearing the called station; a privacy message shall be indicated on the master station display.
- s. Master Station-to-Master Station Calls:
  - 1) Master stations shall be capable of calling other master stations using the handset.
  - 2) Calls from master stations shall be answered using the handset only.
  - 3) Busy master stations shall be indicated by a master station intercom busy tone.
- t. Voice Paging:
  - 1) Capable of voice paging to all stations using a single "All Call" key. The page shall be preceded by an optional pre-announce tone, **as directed**.
  - 2) Capable of voice paging to eight user-defined groups of stations by selecting the group and then the "All Call" key. The page shall be preceded by a pre-announce tone, **as directed**.
  - 3) Capable of voice paging to all staff/duty stations and all patient stations where staff has registered presence using a single "Public Address (PA)/Staff" key. The page shall be preceded by a pre-announce tone, **as directed**.
  - 4) Capable of voice paging through a third-party PA system.
  - 5) Capable of including or excluding any station from the voice paging function(s).
  - 6) Automatically places an active station call on hold during any page and reestablishes the connection at the end of the page.
  - 7) Automatically cancels a page if the talk mode is inactive for more than 15 seconds.
- u. Station Monitor:
  - 1) An audio monitor feature shall allow a user to sequentially or simultaneously listen to one or all stations that are included in the user-created list.
  - 2) Master station display shall indicate which station is being monitored when in sequential mode.
  - 3) The dwell time each station is monitored shall be user programmable.
  - 4) The user shall be able to stop the monitoring sequence by activating a "pause" key.



- 5) The user shall be able to manually sequence through stations using a "next" key.
- v. Night Service:
  - 1) Functions shall be adaptable for nighttime staffing levels, patient traffic, and day/night operations.
  - 2) Staff Follow:
    - a) Capable of locating roving staff; forwarding visual and audible annunciation of incoming calls to station(s) where personnel have registered presence.
    - b) Master station shall display locations where staff have registered presence.
    - c) Incorporates a programmable timer that automatically cancels a forgotten staff presence registration.
  - 3) Tones:
    - a) Deactivates audio signals from a duty station and mini-master display telephones.
    - b) Capable of changing the tone volume at the master and duty stations.
    - c) Satellite function shall permit the user to deactivate audio signals from duty stations and other remote annunciator devices.
  - 4) Transfer:
    - a) Permits one nurse station to take control of all or individually selected bed call cords from another nurse station. It shall be possible to view transfer status of a nurse station.
    - b) Includes a minimum of three transfer modes to allow one nurse station to take control or share calls and operations from another nurse station.
      - i. Parallel Transfer Mode: Permits both nurse stations to share all calls and operations.
      - ii. Supervised Transfer Mode: Permits the transferred nurse station to share all calls and operations with the controlling nurse station; however, the controlling nurse station calls are not shared with the transferring station.
      - iii. Capture Transfer Mode: Transfers all calls and operations from the transferred nurse station to the controlling nurse station.
      - iv. Transferred station shall have no control over calls, and its display shall indicate calls have been transferred to another station.
    - c) Includes two "patient swing" modes to allow one nurse station to take control or share calls from one or many calls from another nurse station.
      - i. Supervised Transfer Mode: Permits the transferred calls to be shared with the controlling nurse station.
      - ii. Capture Transfer Mode: Transfers all calls from the call cord from the transferred nurse station to the controlling nurse station.
      - iii. Transferred station has no control over those transferred calls.
- w. Service Request:
  - 1) Permits users to assign a service request to a substation, at programmable priority level.
  - 2) Displays service request on the nurse station display and light the green flashing corridor lamp at the respective substation and automatically generate a service reminder request.
  - 3) Cancels service requests only at the initiating point.
  - 4) Recall calls shall sound and be displayed at the master station if the service request has not been cancelled at the initiating point within the programmed period of time.
- x. Call Reminder Function:
  - 1) Automatically generates a reminder call for a patient- or staff-initiated, high-priority 2 **OR 3 OR 4, as directed**, request that has had the call tones silenced, allowing time to physically attend to the request and cancel the call at the initiating point.
  - 2) Regenerated calls shall display the same tones and visual indications and priority as the original call and shall also display a "regenerated call" message.
  - 3) Capable of manually adding low-priority calls to the reminder list.

- 4) "Call Reminder" function and reminder timer shall be programmable by call priority.
- y. Hide Function: Prevents a selected station from displaying calls or generating tones on the nurse station.
- z. Door Control Function: Capable of being programmed to enable the user to remotely activate electric door locks.
- aa. Test and Diagnostics Feature:
  - 1) Able to automatically diagnose system faults and categorize them as warnings, communication errors, or fatal errors.
  - 2) Warnings shall indicate possible system problems.
  - 3) Communication errors shall indicate the inability of the master station to communicate with a substation or another nurse-call station.
  - 4) Fatal errors shall indicate a major hardware or software failure.
- bb. User-Configured System Programming - Access Code Not Required:
  - 1) Patient call-cord priority levels.
  - 2) Monitor list.
  - 3) "All Call" list.
  - 4) Master station communication parameters (volume, filtering, talk/listen, sensitivity).
  - 5) Master and duty station call annunciation tone volume.
  - 6) Date/time.
  - 7) Staff-follow operating mode.
  - 8) Transfer type.
  - 9) Pocket pager list assignment.
  - 10) Presence mode.
- cc. User-Configured System Programming - Access Code Required:
  - 1) Master station number.
  - 2) Room device type.
  - 3) Room number.
  - 4) Bed number.
  - 5) Bed alpha or numeric.
  - 6) Reminder duration.
  - 7) Staff presence registration cancel duration.
  - 8) Display language.
  - 9) Paging group assignment(s).
  - 10) Zone group assignments.
  - 11) Monitoring duration.
  - 12) Pocket pager number.
  - 13) Call tone assignment by priority.
  - 14) Pretone activation.
  - 15) Call tones minimum volume.
  - 16) Clock mode (12 h/24 h).
2. Master Station:
  - a. Speaker/microphone unit with operating controls.
  - b. Indicator lamps with legends or by digital display designate identification and priority of calling stations and called stations.
  - c. Pulse rate of incoming-call lights denotes priority of calls awaiting response.
  - d. Station Selection Controls: Touchpad select stations for two-way voice communications.
  - e. Signal Tones: Programmable to announce incoming calls.
  - f. Pulse rate and frequency of tone identify the highest priority call awaiting response at one time.
  - g. Volume Control: Regulates incoming-call volume.
  - h. Privacy Handset with Hook Switch: Of the type that does not require push-to-talk switch attached to each station unless otherwise indicated.
  - i. Staff Reminder Control: Initiates flashing of corresponding corridor dome lights for patients requiring service. Permits scanning equipment to indicate which patients are currently in reminder status.

- j. Call Priority Selection: Controls associated with patient-station selection switches determine the priority displayed when a call is initiated at a patient station.
- 3. Central Equipment Cabinet:
  - a. Lockable metal.
  - b. Houses amplifiers, tone generators, power supplies, controls, terminal strips, and other components.
  - c. Amplifier: With fidelity and overall gain necessary to achieve the sound-transmission and reproduction characteristics specified, considering interoperability with the installed speakers/microphones and wiring.
    - 1) Power Output: Not less than 3 W at a total harmonic distortion not exceeding 5 percent.
    - 2) Hum and Noise: 60 dB below full output with normal input open.
    - 3) Volume Control: Concealed within the amplifier unit to control the volume of sound reproduced at all stations.
    - 4) Protection: Circuit to prevent damage to the amplifier in case of shorted or open circuit.
  - d. Selective Paging Amplifiers: Plug-in card mounted in central equipment cabinet, rated 15 W.
  - e. System Power Supply:
    - 1) 24-V dc for operation of the call system.
    - 2) Equipment Rating: Suitable for continuous operation between 32 and 120 deg F (0 and 49 deg C), from a primary line voltage between 105- to 125-V ac, 60 Hz.
    - 3) Output: Regulated 24-V dc with protection against overloads. Line-to-load regulation shall not exceed 2-1/2 percent with ripple and noise remaining below the 10-mV, rms level.
    - 4) Overload Protection: Electronic fold-back circuit set to limit the volt-ampere output to less than 100 VA during overloaded or shorted output. Restore power output automatically on removal of overload without resetting circuit breakers or replacing fuses.
  - f. Power-on indicator lamp.
  - g. Surge Protector Device: Comply with Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" for auxiliary panel suppressors, with digital indicator lights for power and protection status.
  - h. Battery Backup Unit: Sealed nickel-cadmium, wet-cell battery supplies power through an automatic switch when normal power fails, for a period of not less than six minutes at rated output.
    - 1) Automatic retransfer to normal power, after a 15-minute time delay.
    - 2) Two-rate battery charger with an automatic trickle rate and a recharge rate.
- 4. Speaker/Microphones:
  - a. Type: Permanent-magnet, dynamic or ceramic, protected against dust and humidity.
  - b. Sound Reproduction: Sound level of 90 dB plus or minus 3 dB at a distance of 48 inches (1220 mm) on the axis without overdriving or distorting any frequencies between 300 and 3000 Hz when installed in an enclosure or in the pillow speaker.
  - c. Power Handling Capacity: Not susceptible to damage from overdriving within the range of power available from the amplifier.
  - d. Impedance Matching: Coordinated and matched to the input and output circuits of the amplifier, both for single connection and for group monitoring, to provide the sound reproduction specified. Subsystems or components shall not be combined, which could cause unacceptable distortion such as feedback between pillow speakers and unmuted room speaker/microphone combinations. This protection shall extend throughout the entire range of operation (volume control) of all components.
- 5. Single-Patient Station: Speaker/microphone with 2-inch (50-mm) dynamic cone, a polarized receptacle to match the cord-set plug, monitor lamp, reset switch, and call-placed lamp; assembled under a single faceplate.
- 6. Dual-Patient Station:

- a. Speaker/microphone with 2-inch (50-mm) dynamic cone, two polarized receptacles to match cord-set plugs, monitor lamp, and reset switch; assembled under a single faceplate.
- b. Single call-placed lamp serves both beds.
- OR
- Dual call-placed lamps, one for each bed.
7. Staff/Duty Stations: Audible call-tone signal device, speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, routine-call lamp, emergency-call lamp, and call push button; assembled under a single faceplate.
8. Code Blue Station: Audible call-tone signal device, speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, Code Blue emergency-call lamp, and call push button; assembled under a single faceplate.
9. Ambulatory-Patient Station: Speaker/microphone with 2-inch (50-mm) dynamic cone, monitor lamp, reset switch, call-placed lamp, and call push button; assembled under a single faceplate.
10. Selective Paging Speakers: 8-inch (200-mm) cone type with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet, multitap matching transformer, flush-mounted steel back-box, and white enamel-finished metal ceiling grille.
11. Call Priority Switch Station: Three-position, tamper-resistant priority selection switch. Positions designated by labeling "Normal," "Emergency," and "Priority."
12. Staff Reminder Cancel Switch Station: Momentary contact.
- D. System Components
  1. Emergency-Call Station: Locking-type push button, labeled "Push to Call Help"; reset trigger to release push button and cancel call; and call-placed lamp, mounted in a single faceplate.
  2. Emergency-Bath Station:
    - a. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "URGENT" in bold letters.
    - b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
    - c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
    - d. Water resistant and able to withstand routine cleaning and chemical disinfectants.
    - e. Uses magnetic reed switch technology for reliability and corrosion resistance.
    - f. Mounts on a single-gang electrical box wire to the respective patient station or input controller.
  3. Code Blue Station:
    - a. Consists of a sliding, chemical-resistant, ABS blue fascia marked with the word "CODE" in bold letters.
    - b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
    - c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
    - d. Water resistant and able to withstand routine cleaning and chemical disinfectants.
    - e. Uses magnetic reed switch technology for reliability and corrosion resistance.
    - f. Mounts on a single-gang electrical box wire to the respective patient station or input controller.
  4. Staff, Emergency Station:
    - a. Consists of a sliding, chemical-resistant, ABS red fascia marked with the word "EMERGENCY" in bold letters.
    - b. Capable of being activated with nylon pull cord or by sliding the face of the unit downwards.
    - c. Activation of the station shall illuminate a reassurance digital display on the face of the unit in addition to notifying the master station.
    - d. Mounts on a single-gang electrical box wire to the input controller.
  5. Pull-Cord-Call Station:
    - a. Pull-Down Switch: Lever-locking type, labeled "Pull Down to Call Help."
    - b. Reset trigger.



- c. Call-placed lamp.
- d. Water-resistant construction.
- 6. Patient Control Unit:
  - a. Equipped with plug and **96-inch- (2400-mm-)** long white cord.
  - b. Ethylene oxide, sterilizable.
  - c. Light-Control Switch: Arranged for independent on-off control of patient's up and down light.
  - d. Integral Speaker: **2 inches (50 mm)**, with **0.35-oz. (9.9-g)** magnet, rated 0.2 W.
  - e. Controls: Speaker volume, TV control, and nurse call.
  - f. Housing: High-impact white plastic.
  - g. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
  - h. Quantity: 12 units for every 10 patient beds.
- 7. Call-Button Cord Set:
  - a. Plug and **72-inch (1800-mm)** white cord; cord set shall be resistant to medical gas environment equipped with momentary-action, call-button switch.
  - b. Ethylene oxide, sterilizable.
  - c. Washable cord.
  - d. Palladium switch contacts in high-impact white housing with cord-set strain relief.
  - e. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
  - f. Quantity: Three cord sets for every 10 patient beds.
- 8. Geriatric Call-Button Cord Set:
  - a. Plug and **72-inch (1800-mm)** white cord.
  - b. Resistant to medical gas environment equipped with momentary-action, light-pressure switch in soft outer jacket.
  - c. Ethylene oxide, sterilizable.
  - d. Washable cord.
  - e. Palladium switch contacts in high-impact white housing with cord-set strain relief.
  - f. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
  - g. Quantity: Two cord sets for every 10 patient beds.
- 9. Squeeze-Bulb Switch Cord Set:
  - a. Plug and **72-inch (1800-mm)** washable tube with white cord set.
  - b. Resistant to medical gas environment; washable; equipped with neoprene squeeze-bulb activator, and plug-mounted, momentary contact switch.
  - c. Ethylene oxide, sterilizable.
  - d. Attachment: Stainless-steel bed clamp with permanently attached polyester film strap.
  - e. Quantity: Two cord sets for every 10 patient beds.
- 10. Breath Call Cord:
  - a. Flexible PVC jacketed cable and a momentary contact air-pressure sensitive switch.
  - b. Cord: **108 inches (2700 mm)** long.
  - c. Include an adjustable arm for clamping and suitable for use in oxygen atmospheres.
  - d. Include 12 replacement straws.
- 11. Pillow Speakers:
  - a. Eight-conductor, DIN, flexible PVC jacketed cable.
  - b. Contain nurse-call button, volume control, speaker, and channel control in molded flame-retardant ABS housing.
  - c. Cord: **96 inches (2400 mm)** long with sheet clip.
- 12. Call-Button Plug:
  - a. Designed to plug into patient station cord-set receptacle.
  - b. Button switches call circuit.
  - c. Two plugs for every 10 patient beds.
- 13. Dummy Plugs:
  - a. Designed to plug into patient station cord-set receptacle when call-button plug or patient cord set is not used.
  - b. Three plugs for every 10 patient beds.
- 14. Indicator Lamps: Digital type with rated life of 20 years unless otherwise indicated.

15. Station Faceplates:
  - a. Stainless steel, a minimum of 0.0375 inch (0.95 mm) thick.
  - b. Finish: Brushed.
  - c. Machine-engraved labeling identifies indicator lamps and controls.

**OR**

Station Faceplates:

  - a. High-impact plastic.
  - b. Color: Beige.
  - c. Molded or machine-engraved labeling identifies indicator lamps and controls.
16. Corridor Dome Lights and Zone Lights:
  - a. Three-lamp signal lights.
  - b. Lamps: Front replaceable without tools, low voltage with rated life of 7500 hours. Barriers are such that only one color is displayed at a time.
  - c. Lenses: Heat-resistant, shatterproof, translucent polymer that will not deform, discolor, or craze when exposed to hospital cleaning agents.
  - d. Filters: Two per unit, amber and red.
17. Cable:
  - a. Conductors: Jacketed single and multiple, twisted-pair copper cables.
  - b. Sizes and Types: As recommended by equipment manufacturer.
  - c. Cable for Use in Plenums: Listed and labeled for plenum installation.
18. Grounding Components: Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

E. Software Requirements

1. Telephone System Interface:
  - a. Permits use of wired and/or wireless telephones to execute nurse-call master station.
  - b. Two-way communication with patient and staff stations.
  - c. Two-way communication with the master nurse station.
  - d. "All Call," group call, and staff call paging.
  - e. Capable of being programmed to forward calls destined for a master nurse station to any connected telephone.
  - f. Telephones connected to the telephone interface shall have the same call tone ring patterns as those generated at the master nurse station.
  - g. Telephones having a display shall indicate the call type, priority code, and the calling station number of incoming calls.
  - h. Telephones shall be capable of initiating a service request for a particular patient station, logging calls on the master station's reminder list, and activating door lock mechanisms associated with a call station.
  - i. Capable of routine setup and configuration changes using the keypads on display telephone and/or the master station.
2. Display Telephones:
  - a. Digital telephones for use as mini-master nurse-call stations.
  - b. Digital display shall indicate the call type, priority code, and calling station number of incoming calls.
  - c. Ring patterns shall be identical to those generated at the master station.
  - d. Capable of two-way communication with patient and staff stations and the master station, and other telephones interfaced with the system.
  - e. Capable of placing or answering outside calls when interfaced with the facility telephone system.
  - f. Capable of "All Call," group call, and staff call paging and of initiating service requests, logging calls to the reminder list, and activating optional door controls.
3. Third-Party Pocket Pager Interface:
  - a. Equipped with a standalone pocket pager interface.
  - b. Connects with the facility paging system and transmit alphanumeric messages to the pocket pagers as preprogrammed in the system.
4. Statistical Software:



- a. Includes a data statistical software package that stores, sorts, and analyzes activities occurring on the nurse-call system network.
  - b. Windows based and operated on a PC that is connected to the nurse-call system network.
  - c. Stores events on the PC's hard disk. Accumulation of these stored events shall make up the database that is used to generate reports and statistics.
  - d. Events stored by the software shall include date, day of week, time, ward, priority, and room number.
  - e. Capable of assigning a patient name to bed number.
  - f. Stored events shall include, but not be limited to, calls placed, call priority, calls cancelled at the nurse station, calls cancelled at the point of origin, regenerated calls, calls answered, calls sent to pager interface, staff presence registration, staff presence cancellation, service request, service cancellation, and system and network error messages.
5. Data Analysis Software:
- a. Capable of analyzing the stored information and generating computed analysis.
  - b. Analysis of the database can be conducted by specifying one, many, or all of the following parameters of the database: date, day of week, time, wards, priority, and room number.
  - c. Analysis shall include, but not be limited to, total number of calls placed, average call response time (from call placed to call cancellation), total number of presence registrations, average presence time in a room, total number of service requests, average response time (from audio answer to call cancellation), and average ring time (from call placed to audio answer).
6. Statistical Software Package:
- a. Capable of displaying multiple calls/events on a PC monitor or on a RS-485 data-bus-driven digital display panel.
  - b. Calls from patient or staff stations and associated devices shall be displayed by priority. Display shall be customizable as follows:
    - 1) Choice of color by type of call.
    - 2) Choice of display size (character size).
    - 3) Choice of priority levels, type of events, points of origin.
    - 4) Identification of facility.
    - 5) Identification of ward.
    - 6) Identification of patient with specific patient information.

F. Conductors And Cables

1. Audio Cables:
  - a. Conductors: Jacketed, twisted-pair and twisted-multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
  - b. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
  - c. Shielding: For speaker/microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
  - d. Minimum Shielding Coverage on Conductors: 60 percent.
  - e. Plenum Cable: Listed and labeled for plenum installation.
2. Data Cable and Hardware: Category 5e **OR** Category 6, **as directed**, UTP and UTP hardware. Comply with requirements in Division 27 Section "Communications Horizontal Cabling".
3. Power Conductors and Cables: Copper, solid, No. 20 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
4. Grounding Conductors and Cables: Copper, stranded, No. 16 AWG. Comply with requirements in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

### 1.3 EXECUTION

A. Installation

1. Wiring Method:

- a. Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**.
    - 1) Install plenum cable in environmental air spaces, including plenum ceilings.
    - 2) Conceal raceway and cables except in unfinished spaces.
  - b. Cable Trays: Comply with requirements in Division 27 Section "Communications Horizontal Cabling".
  - c. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used, **as directed**.
    - 1) Outlet boxes shall be no smaller than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
  2. Install cables without damaging conductors, shield, or jacket.
  3. Do not bend cables, while handling or installing, to radii smaller than as recommended by manufacturer.
  4. Pull cables without exceeding cable manufacturer's recommended pulling tensions.
    - a. Pull cables simultaneously if more than one is being installed in same raceway.
    - b. Use pulling compound or lubricant if necessary. Use compounds that will not damage conductor or insulation.
    - c. Use pulling means, including fish tape, cable, rope, and basket-weave wire or cable grips, that will not damage media or raceway.
  5. Install exposed raceways and cables parallel and perpendicular to surfaces or exposed structural members, and follow surface contours. Secure and support cables by straps, staples, or similar fittings designed and installed so as not to damage cables. Secure cable at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, or fittings.
  6. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
  7. Separation of Wires: Separate speaker/microphone, line-level, speaker-level, and power-wiring runs. Run in separate raceways or, if exposed or in same enclosure, provide **12-inch (300-mm)** minimum separation between conductors to speaker/microphones and adjacent parallel power and telephone wiring. Provide separation as recommended by equipment manufacturer for other conductors.
  8. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Install terminal cabinets where there are splices, taps, or terminations for eight or more conductors.
  9. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks if required.
  10. Identification of Conductors and Cables: Comply with requirements in Division 27 Section "Communications Horizontal Cabling" for cable administration, cable schedule, and cable and wire identification.
  11. Equipment Identification:
    - a. Comply with requirements in Division 26 Section "Identification For Electrical Systems" for equipment labels and signs and labeling installation requirements.
    - b. Label stations, controls, and indications using approved consistent nomenclature.
- B. Existing Systems
1. Examine existing systems for proper operation, compatibility with new equipment, and deficiencies. If discrepancies or impairments to successful connection and operation of interconnected equipment are found, report them and do not proceed with installation until directed. Schedule existing systems' examination so there is reasonable time to resolve problems without delaying construction.
- C. Grounding
1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other signal impairments.



2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding except at connection to main building ground bus.
3. Grounding Provisions: Comply with requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

D. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
  - a. Schedule tests a minimum of seven days in advance.
  - b. Report: Submit a written record of test results.
  - c. Operational Test: Perform an operational system test and demonstrate proper operations, adjustment, and sensitivity of each station. Perform tests that include originating station-to-station and "All Call" messages and pages at each nurse-call station. Verify proper routing, volume levels, and freedom from noise and distortion. Test each available message path from each station on the system. Meet the following criteria:
    - 1) Speaker Output: 90 dB plus or minus 3 dB, 300 to 3000 Hz, reference level threshold of audibility 0 dB at 0.02 mPa of sound pressure.
    - 2) Gain from patient's bedside station to nurse station, with distortion less than 65 dB (plus or minus 3 dB, 300 to 3000 Hz).
    - 3) Signal-to-Noise Ratio: Hum and noise level at least 45 dB below full output.
  - d. Test Procedure:
    - 1) Frequency Response: Determine frequency response of two transmission paths by transmitting and recording audio tones.
    - 2) Signal-to-Noise Ratio: Measure the ratio of signal to noise of the complete system at normal gain settings using the following procedure: Disconnect a speaker/microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure the ratio of signal to noise and repeat the test for four speaker microphones.
    - 3) Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 300, 400, 1000, and 3000 Hz into each nurse-call equipment amplifier, and measure the distortion in the amplifier output.
3. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify, by the system test, that the total system meets these Specifications and complies with applicable standards. Report results in writing.
4. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
5. Prepare test and inspection reports.

E. Adjusting

1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting sound levels and controls to suit actual occupied conditions. Provide up to three visits to Project during other-than-normal operating hours for this purpose.

F. Demonstration

1. Train Owner's maintenance personnel and caregiver staff to adjust, operate, and maintain nurse-call equipment.

END OF SECTION 26 33 43 00a

## SECTION 26 33 43 00b - PUBLIC ADDRESS AND MASS NOTIFICATION SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of public address and mass notification systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Preamplifiers.
  - b. Power amplifiers.
  - c. Transfer to standby amplifier.
  - d. Microphones.
  - e. Volume limiter/compressors.
  - f. Control console.
  - g. Equipment cabinet.
  - h. Equipment rack.
  - i. Telephone paging adapters.
  - j. Tone generator.
  - k. Monitor panel.
  - l. Loudspeakers.
  - m. Noise-operated gain controllers.
  - n. Microphone and headphone outlets.
  - o. Battery backup power unit.
  - p. Conductors and cables.
  - q. Raceways.

#### C. Definitions

1. Channels: Separate parallel signal paths, from sources to loudspeakers or loudspeaker zones, with separate amplification and switching that permit selection between paths for speaker alternative program signals.
2. VU: Volume unit.
3. Zone: Separate group of loudspeakers and associated supply wiring that may be arranged for selective switching between different channels.

#### D. Performance Requirements

1. Delegated Design: Design supports and seismic restraints for control consoles, equipment cabinets and racks, and components, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Seismic Performance: Supports and seismic restraints for control consoles, equipment cabinets and racks, and components shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components. Include plans, elevations, sections, details, and attachments to other work.

- a. Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Console layouts.
  - c. Control panels.
  - d. Rack arrangements.
  - e. Calculations: For sizing backup battery.
  - f. Wiring Diagrams: For power, signal, and control wiring.
    - 1) Identify terminals to facilitate installation, operation, and maintenance.
    - 2) Single-line diagram showing interconnection of components.
    - 3) Cabling diagram showing cable routing.
  3. Delegated-Design Submittal: For supports and seismic restraints for control consoles, equipment cabinets and racks, and components indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
    - a. Detail fabrication and assembly of supports and seismic restraints for control consoles, equipment cabinets and racks, and components.
  4. Seismic Qualification Certificates: For control consoles, equipment cabinets and racks, accessories, and components, from manufacturer.
    - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
    - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
    - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
  5. Field quality-control reports.
  6. Operation and maintenance data.
- F. Quality Assurance
1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  2. Comply with NFPA 70.

## 1.2 PRODUCTS

### A. Functional Description Of System

1. System Functions:
  - a. Selectively connect any zone to any available signal channel.
  - b. Selectively control sound from microphone outlets and other inputs.
  - c. "All-call" feature shall connect the all-call sound signal simultaneously to all zones regardless of zone or channel switch settings.
  - d. Telephone paging adapter shall allow paging by dialing an extension from any local telephone instrument and speaking into the telephone.
  - e. Produce a program-signal tone that is amplified and sounded over all speakers, overriding signals currently being distributed.
  - f. Reproduce high-quality sound that is free of noise and distortion at all loudspeakers at all times during equipment operation including standby mode with inputs off; output free of non-uniform coverage of amplified sound.

### B. General Equipment And Material Requirements

1. Compatibility of Components: Coordinate component features to form an integrated system. Match components and interconnections for optimum performance of specified functions.
2. Equipment: Comply with UL 813. Equipment shall be modular, using solid-state components, and fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz.



3. Equipment Mounting: Where rack, cabinet, or console mounting is indicated, equipment shall be designed to mount in a **19-inch (483-mm)** housing complying with TIA/EIA-310-D.
  4. Weather-Resistant Equipment: Listed and labeled by a qualified testing agency for duty outdoors or in damp locations.
- C. Preamplifiers
1. Preamplifier: Separately mounted.
  2. Preamplifier: Integral to power amplifier.
  3. Output Power: Plus 4 dB above 1 mW at matched power-amplifier load.
  4. Total Harmonic Distortion: Less than 1 percent.
  5. Frequency Response: Within plus or minus 2 dB from 20 to 20,000 Hz.
  6. Input Jacks: Minimum of two. One matched for low-impedance microphone; the other matchable to cassette deck, CD player, or radio tuner signals without external adapters.
  7. Minimum Noise Level: Minus 55 dB below rated output.
  8. Controls: On-off, input levels, and master gain.
- D. Power Amplifiers
1. Mounting: Console **OR** Rack, **as directed**.
  2. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.
  3. Total Harmonic Distortion: Less than 3 percent at rated power output from 50 to 12,000 Hz.
  4. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
  5. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
  6. Output Regulation: Less than 2 dB from full to no load.
  7. Controls: On-off, input levels, and low-cut filter.
  8. Input Sensitivity: Matched to preamplifier and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphone or handset transmitter.
- E. Transfer To Standby Amplifier
1. Monitoring Circuit and Sensing Relay: Detect reduction in output of power amplifier of 40 percent or more and, in such event, transfer load and signal automatically to standby amplifier.
- F. Microphones
1. Paging Microphone:
    - a. Type: Dynamic, with cardioid **OR** omni, **as directed**, polar characteristic.
    - b. Impedance: 150 ohms.
    - c. Frequency Response: Uniform, 50 to 14,000 Hz.
    - d. Output Level: Minus 58 dB, minimum.
    - e. Finish: Satin chrome.
    - f. Cable: C25J.
    - g. Mounting: Desk stand with integral-locking, press-to-talk switch.
- G. Volume Limiter/Compressor
1. Minimum Performance Requirements:
    - a. Frequency Response: 45 to 15,000 Hz, plus or minus 1 dB minimum.
    - b. Signal Reduction Ratio: At least a 10:1 and 5:1 selectable capability.
    - c. Distortion: 1 percent, maximum.
    - d. Rated Output: Minimum of plus 14 dB.
    - e. Inputs: Minimum of two inputs with variable front-panel gain controls and VU or decibel meter for input adjustment.
    - f. Rack mounting.
- H. Control Console
1. Cabinet: Modular, desktop **OR** desk style, **as directed**; complying with TIA/EIA-310-D.



2. Housing: Steel, **0.0478 inch (1.2 mm)** minimum, with removable front and rear panels. Side panels are removable for interconnecting side-by-side mounting.
  3. Panel for Equipment and Controls: Rack mounted.
  4. Controls:
    - a. Switching devices to select signal sources for distribution channels.
    - b. Program selector switch to select source for each program channel.
    - c. Switching devices to select zones for paging.
    - d. All-call selector switch.
  5. Indicators: A visual annunciation for each distribution channel to indicate source being used.
  6. Self-Contained Power and Control Unit: A single assembly of basic control, electronics, and power supply necessary to accomplish specified functions.
  7. Spare Positions: 20 percent spare zone control and annunciation positions on console.
  8. Microphone jack.
- I. Equipment Cabinet
1. Comply with TIA/EIA-310-D.
  2. House amplifiers and auxiliary equipment at each location.
  3. Cabinet Housing:
    - a. Constructed of **0.0478-inch (1.2-mm)** steel, minimum, with front- and rear-locking doors and standard TIA/EIA-310-D-compliant, **19-inch (483-mm)** racks.
    - b. Arranged for floor or wall mounting as indicated.
    - c. Sized to house all equipment indicated, plus spare capacity.
    - d. Include 20 percent minimum spare capacity for future equipment in addition to space required for future cassette deck and CD player.
  4. Power Provisions: A single switch in cabinet shall disconnect cabinet power distribution system and electrical outlets, which shall be uniformly spaced to accommodate ac-power cords for each item of equipment.
  5. Ventilation: A low-noise fan for forced-air cabinet ventilation. Fan shall be equipped with a filtered input vent and shall be connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switched; arranged to be powered when main cabinet power switch is on.
- J. Equipment Rack
1. Racks: **19 inches (483 mm)** standard, complying with TIA/EIA-310-D.
  2. Power-Supply Connections: Compatible plugs and receptacles.
  3. Enclosure Panels: Ventilated rear and sides and solid top. Use louvers in panels to ensure adequate ventilation.
  4. Finish: Uniform, baked-enamel factory finish over rust-inhibiting primer.
  5. Power-Control Panel: On front of equipment housing, with master power on-off switch and pilot light; and with socket for 5-A cartridge fuse for rack equipment power.
  6. Service Light: At top rear of rack with an adjacent control switch.
  7. Vertical Plug Strip: Grounded receptacles, **12 inches (300 mm)** o.c.; the full height of rack.
  8. Maintenance Receptacles: Duplex convenience outlets supplied independent of vertical plug strip and located in front and bottom rear of rack.
  9. Spare Capacity: 20 percent in rack for future equipment.
- K. Telephone Paging Adapter
1. Adapters shall accept voice signals from telephone extension dialing access and automatically provide amplifier input and program override for preselected zones.
    - a. Minimum Frequency Response: Flat, 200 to 2500 Hz.
    - b. Impedance Matching: Adapter matches telephone line to public address equipment input.
    - c. Rack mounting.
- L. Tone Generator
1. Generator shall provide clock and program interface with public address and mass notification system.

2. Signals: Minimum of seven distinct, audible signal types including wail, warble, high/low, alarm, repeating and single-stroke chimes, and tone.
  3. Pitch Control: Chimes and tone.
  4. Volume Control: All outputs.
  5. Activation-Switch Network: Establishes priority and hierarchy of output signals produced by different activation setups.
  6. Mounting: Rack.
- M. Monitor Panel
1. Monitor power amplifiers.
  2. Components: VU or dB meter, speaker with volume control, and multiple-position rotary selector switch.
  3. Selector Switch and Volume Control: Selective monitoring of output of each separate power amplifier via VU or dB meter and speaker.
  4. Mounting: Rack.
- N. Loudspeakers
1. Cone-Type Loudspeakers:
    - a. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
    - b. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
    - c. Size: 8 inches (200 mm) with 1-inch (25-mm) voice coil and minimum 5-oz. (140-g) ceramic magnet.
    - d. Minimum Dispersion Angle: 100 degrees.
    - e. Rated Output Level: 10 W.
    - f. Matching Transformer: Full-power rated with four taps. Maximum insertion loss of 0.5 dB.
    - g. Surface-Mounting Units: Ceiling, wall, or pendant mounting, as indicated, in steel back boxes, acoustically dampened. Front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and shop primed for field painting.
    - h. Flush-Ceiling-Mounting Units: In steel back boxes, acoustically dampened. Metal ceiling grille with white baked enamel.
  2. Horn-Type Loudspeakers:
    - a. Type: Single-horn units, double-reentrant design, with minimum full-range power rating of 15 W.
    - b. Matching Transformer: Full-power rated with four standard taps. Maximum insertion loss of 0.5 dB.
    - c. Frequency Response: Within plus or minus 3 dB from 250 to 12,000 Hz.
    - d. Dispersion Angle: 130 by 110 degrees.
    - e. Mounting: Integral bracket.
    - f. Units in Hazardous (Classified) Locations: Listed and labeled for environment in which they are located.
- O. Noise-Operated Gain Controller
1. Gain controller shall be designed to continuously sense space noise level and automatically adjust signal level to local speakers.
  2. Frequency Response: 20 to 20,000 Hz, plus or minus 1 dB.
  3. Level Adjustment Range: 20 dB minimum.
  4. Maximum Distortion: 1 percent.
  5. Control: Permits adjustment of sensing level of device.
- P. Outlets
1. Volume Attenuator Station: Wall-plate-mounted autotransformer type with paging priority feature.
    - a. Wattage Rating: 10 W unless otherwise indicated.
    - b. Attenuation per Step: 3 dB, with positive off position.
    - c. Insertion Loss: 0.4 dB maximum.



- d. Attenuation Bypass Relay: Single pole, double throw. Connected to operate and bypass attenuation when all-call, paging, program signal, or prerecorded message features are used. Relay returns to normal position at end of priority transmission.
- e. Label: "PA Volume."
- 2. Microphone Outlet: Three-pole, polarized, locking-type, microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed outlet covers.
- 3. Headphone Outlet (for the Hearing Impaired): Microphone receptacles in single-gang boxes. Equip wall outlets with brushed stainless-steel device plates. Equip floor outlets with gray tapered rubber or plastic cable nozzles and fixed-outlet covers.

Q. Battery Backup Power Unit

- 1. Unit shall be rack mounted, consisting of time-delay relay, sealed lead-calcium battery, battery charger, on-off switch, "normal" and "emergency" indicating lights, and adequate capacity to supply maximum equipment power requirements for one hour of continuous full operation.
- 2. Unit shall supply public address equipment with 12- to 15-V dc power automatically during an outage of normal 120-V ac power.
- 3. Battery shall be on float charge when not supplying system and to transfer automatically to supply system after three to five seconds of continuous outage of normal power, as sensed by time-delay relay.
- 4. Unit shall automatically retransfer system to normal supply when normal power has been reestablished for three to five seconds continuously.

R. Conductors And Cables

- 1. Jacketed, twisted pair and twisted multipair, untinned solid copper.
  - a. Insulation for Wire in Conduit: Thermoplastic, not less than **1/32 inch (0.8 mm)** thick.
  - b. Microphone Cables: Neoprene jacketed, not less than **2/64 inch (0.8 mm)** thick, over shield with filled interstices. Shield No. 34 AWG, tinned, soft-copper strands formed into a braid or approved equivalent foil. Shielding coverage on conductors is not less than 60 percent.
  - c. Plenum Cable: Listed and labeled for plenum installation.

S. Raceways

- 1. Conduit and Boxes: Comply with Division 26 Section "Raceway And Boxes For Electrical Systems". Flexible metal conduit shall not be used, unless directed otherwise.
  - a. Outlet boxes shall be not less than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.

### 1.3 EXECUTION

A. Wiring Methods

- 1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**. Conceal raceway and cables except in unfinished spaces.
  - a. Install plenum cable in environmental air spaces, including plenum ceilings.
  - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
- 2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- 3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

- B. Installation Of Raceways
1. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
  2. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- C. Installation Of Cables
1. Comply with NECA 1.
  2. General Cable Installation Requirements:
    - a. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
    - b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
    - c. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
    - d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
    - e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
    - f. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.
  3. Open-Cable Installation:
    - a. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
    - b. Suspend speaker cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
    - c. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
  4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.
- D. Installation
1. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
  2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
  3. Equipment Cabinets and Racks:
    - a. Group items of same function together, either vertically or side by side, and arrange controls symmetrically. Mount monitor panel above the amplifiers.
    - b. Arrange all inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
    - c. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by panels.
  4. Volume Limiter/Compressor: Equip each zone with a volume limiter/compressor. Install in central equipment cabinet. Arrange to provide a constant input to power amplifiers.
  5. Wall-Mounted Outlets: Flush mounted.
  6. Floor-Mounted Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.

7. Conductor Sizing: Unless otherwise indicated, size speaker circuit conductors from racks to loudspeaker outlets not smaller than No. 18 AWG and conductors from microphone receptacles to amplifiers not smaller than No. 22 AWG.
8. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
9. Speaker-Line Matching Transformer Connections: Make initial connections using tap settings indicated on Drawings.
10. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

E. Grounding

1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
3. Install grounding electrodes as specified in Division 26 Section "Grounding And Bonding For Electrical Systems".

F. Field Quality Control

1. Perform tests and inspections.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
2. Tests and Inspections:
  - a. Schedule tests with at least seven days' advance notice of test performance.
  - b. After installing public address and mass notification systems and after electrical circuitry has been energized, test for compliance with requirements.
  - c. Operational Test: Perform tests that include originating program and page messages at microphone outlets, preamplifier program inputs, and other inputs. Verify proper routing and volume levels and that system is free of noise and distortion.
  - d. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
    - 1) Disconnect microphone at connector or jack closest to it and replace it in the circuit with a signal generator using a 1000-Hz signal. Replace all other microphones at corresponding connectors with dummy loads, each equal in impedance to microphone it replaces. Measure signal-to-noise ratio.
    - 2) Repeat test for each separately controlled zone of loudspeakers.
    - 3) Minimum acceptance ratio is 50 dB.
  - e. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 50, 200, 400, 1000, 3000, 8000, and 12,000 Hz into each preamplifier channel. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 3 percent total harmonics.
  - f. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each zone. For spaces with seated audiences, maximum permissible variation in level is plus or minus 2 dB. In addition, the levels between locations in same zone and between locations in adjacent zones must not vary more than plus or minus 3 dB.
  - g. Power Output Test: Measure electrical power output of each power amplifier at normal gain settings of 50, 1000, and 12,000 Hz. Maximum variation in power output at these frequencies must not exceed plus or minus 1 dB.
  - h. Signal Ground Test: Measure and report ground resistance at public address equipment signal ground. Comply with testing requirements specified in Division 26 Section "Grounding And Bonding For Electrical Systems".

3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging speaker-line matching transformers.
4. Public address and mass notification systems will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.
  - a. Include a record of final speaker-line matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.

END OF SECTION 26 33 43 00b

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## SECTION 26 33 53 00 - STATIC UNINTERRUPTIBLE POWER SUPPLY

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for static uninterruptible power supply. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Three-phase, on-line, double-conversion, static-type, UPS units with the following features:
    - 1) Surge suppression.
    - 2) Input harmonics reduction.
    - 3) Rectifier-charger.
    - 4) Inverter.
    - 5) Static bypass transfer switch.
    - 6) Battery and battery disconnect device.
    - 7) Internal and External maintenance bypass/isolation switch.
    - 8) Output isolation transformer.
    - 9) Remote UPS monitoring provisions.
    - 10) Battery monitoring.
    - 11) Remote monitoring.

#### C. Definitions

1. EMI: Electromagnetic interference.
2. LCD: Liquid-crystal display.
3. LED: Light-emitting diode.
4. PC: Personal computer.
5. THD: Total harmonic distortion.
6. UPS: Uninterruptible power supply.

#### D. Performance Requirements

1. Seismic Performance: UPS shall withstand the effects of earthquake motions determined according to ASCE/SEI 7, **as directed**.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of product indicated. Include data on features, components, ratings, and performance.
2. Shop Drawings: For UPS. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, components, and location and identification of each field connection. Show access, workspace, and clearance requirements; details of control panels; and battery arrangement.
  - b. Wiring Diagrams: For power, signal, and control wiring.
3. Seismic Qualification Certificates: For UPS equipment, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.





- c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- 4. Factory Test Reports: Comply with specified requirements.
- 5. Field quality-control reports.
- 6. Operation and maintenance data.
- 7. Warranties: Sample of special warranties.

F. Quality Assurance

- 1. Testing Agency Qualifications: Member company of NETA or an NRTL **OR** one who meets the requirements necessary for certification, **as directed**.
  - a. Testing Agency's Field Supervisor: Currently certified by NETA **OR** one who meets the requirements necessary for certification, **as directed**, to supervise on-site testing.
- 2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- 3. UL Compliance: Listed and labeled under UL 1778 by an NRTL.
- 4. NFPA Compliance: Mark UPS components as suitable for installation in computer rooms according to NFPA 75.

G. Warranty

- 1. Special Battery Warranties: Specified form in which manufacturer and Installer agree to repair or replace UPS system storage batteries that fail in materials or workmanship within specified warranty period.
  - a. Warranted Cycle Life for Valve-Regulated, Lead-Calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of **77 deg F (25 deg C)**:

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	6 cycles
30 minutes	30 minutes	1.67	20 cycles
15 minutes	45 seconds	1.67	120 cycles

**OR**

Warranted Cycle Life for Premium Valve-Regulated, Lead-calcium Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of **77 deg F (25 deg C)**:

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.67	40 cycles
30 minutes	30 minutes	1.67	125 cycles
15 minutes	1.5 minutes	1.67	750 cycles

**OR**

Warranted Cycle Life for Flooded Batteries: Equal to or greater than that represented in manufacturer's published table, including figures corresponding to the following, based on annual average battery temperature of **77 deg F (25 deg C)**:

Discharge Rate	Discharge Duration	Discharge End Voltage	Cycle Life
8 hours	8 hours	1.75	40 cycles
1 hour	1 hour	1.75	80 cycles
15 minutes	45 seconds	1.67	2700 cycles

2. Special UPS Warranties: Specified form in which manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within Two **OR** Three, **as directed**, years from date of Final Completion.

## 1.2 PRODUCTS

### A. Operational Requirements

1. Automatic operation includes the following:
  - a. Normal Conditions: Load is supplied with power flowing from the normal power input terminals, through the rectifier-charger and inverter, with the battery connected in parallel with the rectifier-charger output.
  - b. Abnormal Supply Conditions: If normal supply deviates from specified and adjustable voltage, voltage waveform, or frequency limits, the battery supplies energy to maintain constant, regulated inverter power output to the load without switching or disturbance.
  - c. If normal power fails, energy supplied by the battery through the inverter continues supply-regulated power to the load without switching or disturbance.
  - d. When power is restored at the normal supply terminals of the system, controls automatically synchronize the inverter with the external source before transferring the load. The rectifier-charger then supplies power to the load through the inverter and simultaneously recharges the battery.
  - e. If the battery becomes discharged and normal supply is available, the rectifier-charger charges the battery. On reaching full charge, the rectifier-charger automatically shifts to float-charge mode.
  - f. If any element of the UPS system fails and power is available at the normal supply terminals of the system, the static bypass transfer switch switches the load to the normal ac supply circuit without disturbance or interruption.
  - g. If a fault occurs in the system supplied by the UPS, and current flows in excess of the overload rating of the UPS system, the static bypass transfer switch operates to bypass the fault current to the normal ac supply circuit for fault clearing.
  - h. When the fault has cleared, the static bypass transfer switch returns the load to the UPS system.
  - i. If the battery is disconnected, the UPS continues to supply power to the load with no degradation of its regulation of voltage and frequency of the output bus.
2. Manual operation includes the following:
  - a. Turning the inverter off causes the static bypass transfer switch to transfer the load directly to the normal ac supply circuit without disturbance or interruption.
  - b. Turning the inverter on causes the static bypass transfer switch to transfer the load to the inverter.
3. Maintenance Bypass/Isolation Switch Operation: Switch is interlocked so it cannot be operated unless the static bypass transfer switch is in the bypass mode. Device provides manual selection among the three conditions in subparagraphs below without interrupting supply to the load during switching:
  - a. Full Isolation: Load is supplied, bypassing the UPS. Normal UPS ac input circuit, static bypass transfer switch, and UPS load terminals are completely disconnected from external circuits.
  - b. Maintenance Bypass: Load is supplied, bypassing the UPS. UPS ac supply terminals are energized to permit operational checking, but system load terminals are isolated from the load.
  - c. Normal: Normal UPS ac supply terminals are energized and the load is supplied through either the static bypass transfer switch and the UPS rectifier-charger and inverter, or the battery and the inverter.
4. Environmental Conditions: The UPS shall be capable of operating continuously in the following environmental conditions without mechanical or electrical damage or degradation of operating capability, except battery performance.
  - a. Ambient Temperature for Electronic Components: 32 to 104 deg F (0 to 40 deg C).

- b. Ambient Temperature for Battery: **41 to 95 deg F (5 to 35 deg C)**.
- c. Relative Humidity: 0 to 95 percent, noncondensing.
- d. Altitude: Sea level to **4000 feet (1220 m)**.

**B. Performance Requirements**

1. The UPS shall perform as specified in this article while supplying rated full-load current, composed of any combination of linear and nonlinear load, up to 100 percent nonlinear load with a load crest factor of 3.0, under the following conditions or combinations of the following conditions:
  - a. Inverter is switched to battery source.
  - b. Steady-state ac input voltage deviates up to plus or minus 10 percent from nominal voltage.
  - c. Steady-state input frequency deviates up to plus or minus 5 percent from nominal frequency.
  - d. THD of input voltage is 15 percent or more with a minimum crest factor of 3.0, and the largest single harmonic component is a minimum of 5 percent of the fundamental value.
  - e. Load is 30 **OR** 50 **OR** 100, **as directed**, percent unbalanced continuously.
2. Minimum Duration of Supply: If battery is sole energy source supplying rated full UPS load current at 80 percent power factor, duration of supply is five **OR** 10 **OR** 15, **as directed**, minutes.
3. Input Voltage Tolerance: System steady-state and transient output performance remains within specified tolerances when steady-state ac input voltage varies plus 10, minus 15 **OR** 20 **OR** 30, **as directed**, percent from nominal voltage.
4. Overall UPS Efficiency:

**NOMINAL OVERALL UPS EFFICIENCY RATINGS**

SIZE RANGE OF UPS UNITS	EFFICIENCY AT 100% RATED LOAD	EFFICIENCY AT 75% RATED LOAD	EFFICIENCY AT 50% RATED LOAD
30 kVA and Smaller	86	85	84
37.5 to 74 kVA	89	88	87
75 to 124 kVA	90	88	87
125 to 224 kVA	90	89	88
225 kVA and Larger	90	89	88

5. Maximum Acoustical Noise:

**NOMINAL OVERALL UPS AUDIBLE NOISE RATINGS**

SIZE RANGE OF UPS UNITS	MAXIMUM NOISE VALUE	DISTANCE AT WHICH MEASURED
10 kVA and Smaller	58 dB	36 inches (900 mm)
20 to 125 kVA	60 dB	48 inches (1200 mm)
150 to 300 kVA	78 dB	48 inches (1200 mm)
300 kVA and Larger	83 dB	48 inches (1200 mm)

6. Maximum Energizing Inrush Current: Six **OR** Eight, **as directed**, times the full-load current.
7. Maximum AC Output-Voltage Regulation for Loads up to 50 Percent Unbalanced: Plus or minus 2 percent over the full range of battery voltage.
8. Output Frequency: 60 Hz, plus or minus 0.5 percent over the full range of input voltage, load, and battery voltage.
9. Limitation of harmonic distortion of input current to the UPS shall be as follows:

- a. Description: Either a tuned harmonic filter or an arrangement of rectifier-charger circuits shall limit THD to 5 **OR** 10, **as directed**, percent, maximum, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.  
**OR**  
Description: THD is limited to a maximum of 32 percent, at rated full UPS load current, for power sources with X/R ratio between 2 and 30.
  10. Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for 100 percent rated nonlinear load current with a load crest factor of 3.0.  
**OR**  
Maximum Harmonic Content of Output-Voltage Waveform: 5 percent rms total and 3 percent rms for any single harmonic, for rated full load with THD up to 50 percent, with a load crest factor of 3.0.
  11. Minimum Overload Capacity of UPS at Rated Voltage: 125 percent of rated full load for 10 minutes, and 150 percent for 30 seconds in all operating modes.
  12. Maximum Output-Voltage Transient Excursions from Rated Value: For the following instantaneous load changes, stated as percentages of rated full UPS load, voltage shall remain within stated percentages of rated value and recover to, and remain within, plus or minus 2 percent of that value within 100 ms:
    - a. 50 Percent: Plus or minus 5 percent.
    - b. 100 Percent: Plus or minus 5 percent.
    - c. Loss of AC Input Power: Plus or minus 1 percent.
    - d. Restoration of AC Input Power: Plus or minus 1 percent.
  13. Input Power Factor: A minimum of 0.70 **OR** 0.85, **as directed**, lagging when supply voltage and current are at nominal rated values and the UPS is supplying rated full-load current.
  14. EMI Emissions: Comply with FCC Rules and Regulations and with 47 CFR 15 for Class A equipment.
- C. UPS Systems
1. Electronic Equipment: Solid-state devices using hermetically sealed, semiconductor elements. Devices include rectifier-charger, inverter, static bypass transfer switch, and system controls.
  2. Enclosures: Comply with NEMA 250, Type 1, unless otherwise indicated.
  3. Control Assemblies: Mount on modular plug-ins, readily accessible for maintenance.
  4. Surge Suppression: Protect internal UPS components from surges that enter at each ac power input connection including main disconnect switch, static bypass transfer switch, and maintenance bypass/isolation switch, **as directed**. Protect rectifier-charger, inverter, controls, and output components.
    - a. Use factory-installed surge suppressors tested according to IEEE C62.41.1 and IEEE C62.41.2, Category B **OR** Category C, **as directed**.
    - b. Additional Surge Protection: Protect internal UPS components from low-frequency, high-energy voltage surges described in IEEE C62.41.1 and IEEE C62.41.2. Design the circuits connecting with external power sources and select circuit elements, conductors, conventional surge suppressors, and rectifier components and controls so input assemblies will have adequate mechanical strength and thermal and current-carrying capacity to withstand stresses imposed by 40-Hz, 180 percent voltage surges described in IEEE C62.41.1 and IEEE C62.41.2.
  5. Maintainability Features (for units rated more than approximately 100 kVA): Mount rectifier-charger and inverter sections and the static bypass transfer switch on modular plug-ins, readily accessible for maintenance.
  6. Capacity Upgrade Capability: Arrange wiring, controls, and modular component plug-in provisions to permit future 25 percent increase in UPS capacity.
  7. Seismic-Restraint Design: UPS assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.
  8. UPS Cabinet Ventilation: Redundant fans or blowers draw in ambient air near the bottom of cabinet and discharge it near the top rear.

9. Output Circuit Neutral Bus, Conductor, and Terminal Ampacity (for a UPS with heavy nonlinear loading): Rated phase current times a multiple of 1.73, minimum.

**D. Rectifier-Charger**

1. Capacity: Adequate to supply the inverter during rated full output load conditions and simultaneously recharge the battery from fully discharged condition to 95 percent of full charge within 10 times the rated discharge time for duration of supply under battery power at full load.
2. Output Ripple: Limited by output filtration to less than 0.5 percent of rated current, peak to peak.
3. Control Circuits: Immune to frequency variations within rated frequency ranges of normal and emergency power sources.
  - a. Response Time: Field adjustable for maximum compatibility with local generator-set power source.
4. Battery Float-Charging Conditions: Comply with battery manufacturer's written instructions for battery terminal voltage and charging current required for maximum battery life.

**E. Inverter**

1. Description: Pulse-width modulated, with sinusoidal output.  
**OR**  
Description (if the UPS may be supplied power from a standby engine-generator set): Pulse-width modulated, with sinusoidal output. Include a bypass phase synchronization window adjustment to optimize compatibility with local engine-generator-set power source.

**F. Static Bypass Transfer Switch**

1. Description: Solid-state switching device providing uninterrupted transfer. A contactor or electrically operated circuit breaker automatically provides electrical isolation for the switch.
2. Switch Rating: Continuous duty at the rated full UPS load current, minimum.

**G. Battery**

**ALTERNATIVE BATTERY TYPES FOR UPS SYSTEMS**

TYPE	NOMINAL LIFE EXPECTANCY (YEARS)*	TYPICAL WARRANTY (YEARS)*		MINIMUM NOMINAL MAINTENANCE INTERVAL	APPROX. INITIAL COST FACTOR**	SPECIAL FEATURES
		FULL	PRO RATA			
Premium quality, valve regulated, recombinant, lead calcium	20	1	19	1 year	2.5	Spill proof.
Standard quality, valve regulated, recombinant, lead calcium	10	1	9	1 year	1.0	Spill proof.
Nickel cadmium, flooded	25	5	15	3 years	4.0	Can operate in high ambient temperatures. Can be completely discharged without damage.
Lead calcium, flooded	20	1	9	6 months	2.5	-

\*Life expectancy and warranty data apply to installations where batteries are considered to be in a "float-service"

application. Use the data only as a general guide because UPS batteries are typically considered to be in a separate service application category that accounts for the numerous discharges of varying duration they experience.

**\*\*Cost includes an allowance for space requirements and environmental control.**

1. Description: Valve-regulated, recombinant, lead-calcium units, factory assembled in an isolated compartment of UPS cabinet, complete with battery disconnect switch.
  - a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

**OR**

Description: Valve-regulated, premium, heavy-duty, recombinant, lead-calcium units; factory assembled in an isolated compartment or in a separate matching cabinet, complete with battery disconnect switch.

  - a. Arrange for drawout removal of battery assembly from cabinet for testing and inspecting.

**OR**

Description: Flooded, lead-calcium, heavy-duty industrial units in styrene acrylonitrile containers mounted on three-tier, **as directed**, acid-resistant, painted steel racks. Assembly includes battery disconnect switch, intercell connectors, hydrometer syringe, and thermometer with specific gravity-correction scales.
2. Seismic-Restraint Design: Battery racks, cabinets, assemblies, subassemblies, and components (and fastenings and supports, mounting, and anchorage devices for them) shall be designed and fabricated to withstand static and seismic forces.

#### H. Controls And Indications

1. Description: Group displays, indications, and basic system controls on a common control panel on front of UPS enclosure.
2. Minimum displays, indicating devices, and controls include those in lists below. Provide sensors, transducers, terminals, relays, and wiring required to support listed items. Alarms include audible signals and visual displays.
3. Indications: Labeled LED **OR** Plain-language messages on a digital LCD or LED, **as directed**.
  - a. Quantitative indications shall include the following:
    - 1) Input voltage, each phase, line to line.
    - 2) Input current, each phase, line to line.
    - 3) Bypass input voltage, each phase, line to line.
    - 4) Bypass input frequency.
    - 5) System output voltage, each phase, line to line.
    - 6) System output current, each phase.
    - 7) System output frequency.
    - 8) DC bus voltage.
    - 9) Battery current and direction (charge/discharge).
    - 10) Elapsed time discharging battery.
  - b. Basic status condition indications shall include the following:
    - 1) Normal operation.
    - 2) Load-on bypass.
    - 3) Load-on battery.
    - 4) Inverter off.
    - 5) Alarm condition.
  - c. Alarm indications shall include the following:
    - 1) Bypass ac input overvoltage or undervoltage.
    - 2) Bypass ac input overfrequency or underfrequency.
    - 3) Bypass ac input and inverter out of synchronization.
    - 4) Bypass ac input wrong-phase rotation.
    - 5) Bypass ac input single-phase condition.
    - 6) Bypass ac input filter fuse blown.
    - 7) Internal frequency standard in use.
    - 8) Battery system alarm.
    - 9) Control power failure.
    - 10) Fan failure.

- 11) UPS overload.
- 12) Battery-charging control faulty.
- 13) Input overvoltage or undervoltage.
- 14) Input transformer overtemperature.
- 15) Input circuit breaker tripped.
- 16) Input wrong-phase rotation.
- 17) Input single-phase condition.
- 18) Approaching end of battery operation.
- 19) Battery undervoltage shutdown.
- 20) Maximum battery voltage.
- 21) Inverter fuse blown.
- 22) Inverter transformer overtemperature.
- 23) Inverter overtemperature.
- 24) Static bypass transfer switch overtemperature.
- 25) Inverter power supply fault.
- 26) Inverter transistors out of saturation.
- 27) Identification of faulty inverter section/leg.
- 28) Inverter output overvoltage or undervoltage.
- 29) UPS overload shutdown.
- 30) Inverter current sensor fault.
- 31) Inverter output contactor open.
- 32) Inverter current limit.
- d. Controls shall include the following:
  - 1) Inverter on-off.
  - 2) UPS start.
  - 3) Battery test.
  - 4) Alarm silence/reset.
  - 5) Output-voltage adjustment.
4. Dry-form "C" contacts shall be available for remote indication of the following conditions:
  - a. UPS on battery.
  - b. UPS on-line.
  - c. UPS load-on bypass.
  - d. UPS in alarm condition.
  - e. UPS off (maintenance bypass closed).
5. Emergency Power Off Switch: Capable of local operation and operation by means of activation by external dry contacts.

I. Maintenance Bypass/Isolation Switch

1. Description: Manually operated switch or arrangement of switching devices with mechanically actuated contact mechanism arranged to route the flow of power to the load around the rectifier-charger, inverter, and static bypass transfer switch.
  - a. Switch shall be electrically and mechanically interlocked to prevent interrupting power to the load when switching to bypass mode.
  - b. Switch shall electrically isolate other UPS components to permit safe servicing.
2. Comply with NEMA PB 2 and UL 891.
3. Switch Rating: Continuous duty at rated full UPS load current.
4. Mounting Provisions: Internal to system cabinet **OR** Separate wall- or floor-mounted unit, **as directed**.
5. Key interlock requires unlocking maintenance bypass/isolation switch before switching from normal position with key that is released only when the UPS is bypassed by the static bypass transfer switch. Lock is designed specifically for mechanical and electrical component interlocking.

J. Output Isolation Transformer

1. Description: Shielded unit **OR** Unit, **as directed**, with low forward transfer impedance up to 3 kHz, minimum. Include the following features:
  - a. Comply with applicable portions of UL 1561, including requirements for nonlinear load current-handling capability for a K-factor of approximately 4 **OR** 9 **OR** 13 **OR** 20, **as directed**.
  - b. Output Impedance at Fundamental Frequency: Between 3 and 4 percent.
  - c. Regulation: 5 percent, maximum, at rated nonlinear load current.
  - d. Full-Load Efficiency at Rated Nonlinear Load Current: 96 percent, minimum.
  - e. Electrostatic Shielding of Windings: Independent for each winding.
  - f. Coil Leads: Physically arranged for minimum interlead capacitance.
  - g. Shield Grounding Terminal: Separately mounted; labeled "Shield Ground."
  - h. Capacitive Coupling between Primary and Secondary: 33 picofarads, maximum, over a frequency range of 20 Hz to 1 MHz.
- K. Output Distribution Section
  1. Panelboards: Comply with Division 26 Section "Panelboards" except provide assembly integral to UPS cabinet.
- L. Monitoring By Remote Status And Alarm Panel
  1. Description: Labeled LEDs on panel faceplate indicate five basic status conditions. Audible signal indicates alarm conditions. Silencing switch in face of panel silences signal without altering visual indication.
    - a. Cabinet and Faceplate: Surface or flush mounted to suit mounting conditions indicated.
- M. Monitoring By Remote Computer
  1. Description: Communication module in unit control panel provides capability for remote monitoring of status, parameters, and alarms specified in "Controls and Indications" Article. The remote computer and the connecting signal wiring are not included in this Section. Include the following features:
    - a. Connectors and network interface units or modems for data transmission via RS-232 link.
    - b. Software designed for control and monitoring of UPS functions and to provide on-screen explanations, interpretations, diagnosis, action guidance, and instructions for use of monitoring indications and development of meaningful reports. Permit storage and analysis of power-line transient records. Designs for Windows applications, software, and computer are not included in this Section.
    - c. Software and Hardware: Compatible with that specified in Division 26 Section "Electrical Power Monitoring And Control".
- N. Basic Battery Monitoring
  1. Battery Ground-Fault Detector: Initiates alarm when resistance to ground of positive or negative bus of battery is less than 5000 ohms.
  2. Battery compartment smoke/high-temperature detector initiates an alarm when smoke or a temperature greater than 75 deg C occurs within the compartment.
  3. Annunciation of Alarms: At UPS control panel.
- O. Additional Battery Monitoring
  1. Monitoring features and components shall include the following:
    - a. Factory-wired sensing leads to cell and battery terminals and cell temperature sensors.
    - b. Connections for data transmission via RS-232 link, network interface and, **as directed**, modem and, **as directed**, external signal wiring to computer **OR** electrical power monitoring and control equipment, **as directed**. External signal wiring and computer are not specified in this Section.
    - c. PC-based software designed to store and analyze battery data. Software compiles reports on individual-cell parameters and total battery performance trends, and provides data for scheduling and prioritizing battery maintenance.





2. Performance: Automatically measures and electronically records the following parameters on a routine schedule and during battery discharge events. During discharge events, records measurements timed to nearest second; includes measurements of the following parameters:
  - a. Total battery voltage and ambient temperature.
  - b. Individual-cell voltage, impedance, and temperature. During battery-discharging events such as utility outages, measures battery and cell voltages timed to nearest second.
  - c. Individual-cell electrolyte levels.

P. Battery-Cycle Warranty Monitoring

1. Description: Electronic device, acceptable to battery manufacturer as a basis for warranty action, for monitoring of charge-discharge cycle history of batteries covered by cycle-life warranties.
2. Performance: Automatically measures and records each discharge event, classifies it according to duration category, and totals discharges according to warranty criteria, displaying remaining warranted battery life on front panel display.
3. Additional monitoring functions and features shall include the following:
  - a. Measuring and Recording: Total voltage at battery terminals; initiates alarm for excursions outside the proper float-voltage level.
  - b. Monitors: Ambient temperature at battery; initiates alarm if temperature deviates from normally acceptable range.
  - c. Keypad on Device Front Panel: Provides access to monitored data using front panel display.
  - d. Alarm Contacts: Arranged to initiate local **OR** remote, **as directed**, alarm for battery discharge events **OR** abnormal temperature **OR** abnormal battery voltage or temperature, **as directed**.
  - e. Memory: Stores recorded data in nonvolatile electronic memory.
  - f. RS-232 Port: Permits downloading of data to a portable PC.
  - g. Modem: Makes measurements and recorded data accessible to a remote PC via telephone line. Computer is not specified in this Section.

Q. Source Quality Control

1. Factory test complete UPS system before shipment. Use actual batteries that are part of final installation **OR** simulated battery testing, **as directed**. Include the following:
  - a. Test and demonstration of all functions, controls, indicators, sensors, and protective devices.
  - b. Full-load test.
  - c. Transient-load response test.
  - d. Overload test.
  - e. Power failure test.
2. Observation of Test: Give 14 days' advance notice of tests and provide opportunity for Owner's representative to observe tests at Owner's choice.
3. Report test results. Include the following data:
  - a. Description of input source and output loads used. Describe actions required to simulate source load variation and various operating conditions and malfunctions.
  - b. List of indications, parameter values, and system responses considered satisfactory for each test action. Include tabulation of actual observations during test.
  - c. List of instruments and equipment used in factory tests.

### 1.3 EXECUTION

A. Installation

1. Equipment Mounting: Install UPS on concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.

- b. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
      - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
      - d. Install anchor bolts to elevations required for proper attachment to supported equipment.
    2. Maintain minimum clearances and workspace at equipment according to manufacturer's written instructions and NFPA 70.
    3. Connections: Interconnect system components. Make connections to supply and load circuits according to manufacturer's wiring diagrams unless otherwise indicated.
  - B. Grounding
    1. Separately Derived Systems: If not part of a listed power supply for a data-processing room, comply with NFPA 70 requirements for connecting to grounding electrodes and for bonding to metallic piping near isolation transformer.
  - C. Identification
    1. Identify components and wiring according to Division 26 Section "Identification For Electrical Systems".
      - a. Identify each battery cell individually.
  - D. Battery Equalization
    1. Equalize charging of battery cells according to manufacturer's written instructions. Record individual-cell voltages.
  - E. Field Quality Control
    1. Perform tests and inspections.
      - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
    2. Tests and Inspections:
      - a. Comply with manufacturer's written instructions.
      - b. Inspect interiors of enclosures, including the following:
        - 1) Integrity of mechanical and electrical connections.
        - 2) Component type and labeling verification.
        - 3) Ratings of installed components.
      - c. Inspect batteries and chargers according to requirements in NETA Acceptance Testing Specifications.
      - d. Test manual and automatic operational features and system protective and alarm functions.
      - e. Test communication of status and alarms to remote monitoring equipment.
      - f. Load the system using a variable-load bank to simulate kilovolt amperes, kilowatts, and power factor of loads for unit's rating. Use instruments calibrated within the previous six months according to NIST standards.
        - 1) Simulate malfunctions to verify protective device operation.
        - 2) Test duration of supply on emergency, low-battery voltage shutdown, and transfers and restoration due to normal source failure.
        - 3) Test harmonic content of input and output current less than 25, 50, and 100 percent of rated loads.
        - 4) Test output voltage under specified transient-load conditions.
        - 5) Test efficiency at 50, 75, and 100 percent of rated loads.
        - 6) Test remote status and alarm panel functions.
        - 7) Test battery-monitoring system functions.
    3. Seismic-restraint tests and inspections shall include the following:
      - a. Inspect type, size, quantity, arrangement, and proper installation of mounting or anchorage devices.



- b. Test mounting and anchorage devices according to requirements in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
  - 4. The UPS system will be considered defective if it does not pass tests and inspections.
  - 5. Record of Tests and Inspections: Maintain and submit documentation of tests and inspections, including references to manufacturers' written instructions and other test and inspection criteria. Include results of tests, inspections, and retests.
  - 6. Prepare test and inspection reports.
- F. Demonstration
- 1. Train Owner's maintenance personnel to adjust, operate, and maintain the UPS.

END OF SECTION 26 33 53 00

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Task	Specification	Specification Description
26 33 53 00	26 33 43 00	Central Battery Inverters

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## SECTION 26 35 33 16 - POWER FACTOR CORRECTION CAPACITORS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for power factor correction capacitors. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes power and automatic power factor correction equipment rated 600 V and less.

#### C. Performance Requirements

1. Seismic Performance: Power factor correction equipment shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### D. Submittals

1. Product Data: For each type of product indicated. Include dimensions, operating characteristics of multiple capacitor cells or elements, and data on features, ratings, and performance.
2. Shop Drawings: For automatic power factor correction units.
  - a. Detail equipment assemblies and indicate dimensions, weights, method of field assembly, components, and location and size of each field connection. Show access and workspace requirements and required clearances.
  - b. Wiring Diagrams: For power, signal, and control wiring.
3. Qualification Data: For qualified testing agency.
4. Seismic Qualification Certificates: For capacitors, accessories, and components, from manufacturer.
  - a. Basis of Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Field quality-control reports.
6. Operation and Maintenance Data: For equipment to include in emergency, operation, and maintenance manuals. Include the following:
  - a. Lists of spare parts and replacement components recommended for storage at Project site.
  - b. Detailed instructions covering operation under both normal and abnormal conditions.
7. Warranty: Sample of special warranty.

#### E. Quality Assurance

1. Testing Agency Qualifications: Member company of NETA or an NRTL **OR** one who meets the requirements necessary for certification, **as directed**.
  - a. Testing Agency's Field Supervisor: Currently certified by NETA **OR** one who meets the requirements necessary for certification, **as directed**, to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Comply with IEEE 18 and NEMA CP 1.
4. Comply with NFPA 70.



F. Coordination

1. Coordinate sensor-communication module package with data network and with monitoring equipment specified in Division 26 Section "Electrical Power Monitoring And Control" for successful transmission and remote readout of remote monitoring data specified in this Section.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace capacitor-bank components that fail in materials or workmanship within five years from date of Final Completion.

## 1.2 PRODUCTS

A. Capacitors, General

1. Comply with UL 810.
2. Service Conditions: Capacitor equipment suitable for the following conditions:
  - a. Operating Temperature: **Minus 40 to plus 115 deg F (Minus 40 to plus 46 deg C).**
  - b. Maximum Altitude: **6000 feet (1800 m).**
  - c. Humidity: 0 to 95 percent, noncondensing.
3. Construction: Multiple capacitor cells or elements, factory wired in three-phase groups and mounted in metal enclosures.
4. Cells: Dry metallized-dielectric, self-healing type. Each cell shall be encapsulated in thermosetting resin inside plastic container.
5. Rupture Protection: Pressure-sensitive circuit interrupter for each cell.

B. Fixed Capacitors

1. Description: Factory wired, ready for field connection to external circuits at a single set of pressure terminals. Comply with UL 810.
2. Fuses: Current-limiting, noninterchangeable type; factory installed in each phase and located within the equipment enclosure. Features include the following:
  - a. Interrupting Capacity: 100,000 **OR** 200,000, **as directed**, A
  - b. Fuse Ratings and Characteristics: As recommended by capacitor manufacturer.
  - c. Neon Indicator Lamp for Each Fuse: Connect to illuminate when fuse has opened, but is still in place, and locate so it is visible from outside the enclosure.
3. Discharge Resistors: Factory installed and wired.
4. Enclosure: NEMA 250, steel **OR** aluminum, **as directed**, arranged to contain the fluid leakage from capacitor cells; factory equipped with mounting brackets suitable for type of mounting indicated.
  - a. Indoor Enclosures: NEMA 250, Type 12 or as indicated.  
**OR**  
Outdoor Enclosures: NEMA 250, Type 3R or as indicated.  
**OR**  
Outdoor Enclosures: NEMA 250, Type 4, equipped with watertight conduit connections.

C. Automatic Power Factor Correction Units

1. Description: Capacitors, contactors, controls, and accessories factory installed in independent enclosures **OR** motor-control center, with a connection to motor-control center bus, **as directed**, complying with NEMA ICS 2. Comply with UL 810.
2. Performance Requirements: Controls permit selection of a target power factor, adjustable to any value between unity and 0.80 lagging. Controls continuously sense the power factor on circuits being corrected and, when the power factor differs from the target setting for more than 10 seconds, operate a contractor to switch a capacitor bank into or out of the circuit. Contactors are opened or closed as required to bring the corrected circuit power factor closer to the target setting. Provide number of switching steps indicated on the Three-Phase Capacitor-Bank Schedule.

3. Current Transformer: Type, configuration, and ratio to suit sensing and mounting conditions.
4. Main Circuit Breaker: Thermal-magnetic, inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger. Operable from outside the enclosure to disconnect the unit.
5. Controls: Solid-state, microprocessor-based controls, including the following:
  - a. Undervoltage relay that interrupts capacitor switching and disconnects capacitors for power-supply interruptions longer than 15 minutes.
  - b. "Advance" and "Retard" push buttons on the control panel to permit manually controlled capacitor-bank switching.
6. Contactors: Three pole; rated for the repetitive high-inrush-switching duty in the capacitor application.
7. Fuses for Protection of Capacitor Banks: Rated to protect contactor, interconnecting wiring, and capacitors.
  - a. Spare-Fuse Cabinet: Identified and compartmented steel box **OR** cabinet with hinged lockable door, **as directed**.
8. Discharge Resistors: Factory installed and wired.  
**OR**  
Inductors: Air-core type, connected in capacitor circuits; rated to limit switching surges to within contactor ratings.
9. Precharge Capacitor Circuit: Resistive, precharge circuit to charge capacitors prior to switching and to limit switching surges to within contactor ratings.
10. Enclosure: NEMA 250, Type 1 **OR** Type 3R **OR** Type 12, **as directed**, steel or aluminum, with hinged door and hand-operated catch. Door shall be interlocked with controls or main circuit breaker to de-energize capacitors when door is opened.
  - a. Factory Finish: Manufacturer's standard enamel over corrosion-resistant treatment or primer coat.
11. Local Display: LED or liquid-crystal digital type, mounted in door of enclosure, indicating the following:
  - a. Target and actual power factors accurate to plus or minus 1 percent of reading.
  - b. Steps energized.
  - c. Step reconnection delay.
  - d. Real and reactive currents.
  - e. Voltage total harmonic distortion.
  - f. Alarm codes.
12. System Alarms: Alarm relay and local display indication of the following conditions:
  - a. Low power factor.
  - b. Leading power factor.
  - c. Frequency not detected.
  - d. Overcurrent.
  - e. Overvoltage.
  - f. Overtemperature.
  - g. Excessive voltage total harmonic distortion.
  - h. Capacitor overload.
  - i. Loss of capacitance.
13. Remote Monitoring Components: Sensors, associated communication modules, and network interface units, matched to and compatible with electrical power monitoring and control network. Communication module shall have capability to transmit the following data to remote monitoring devices:
  - a. System in alarm.
  - b. Power factor set point.
  - c. Corrected power factor.
  - d. Number of capacitor steps activated.

D. Source Quality Control





1. Factory test power factor correction equipment before shipment. Comply with NEMA CP 1. Include the following:
  - a. Routine capacitor production tests, including short-time overvoltage, capacitance, leak, and dissipation-factor tests.
  - b. Functional test of all operations, controls, indicators, sensors, and protective devices.

### 1.3 EXECUTION

#### A. Installation

1. Install freestanding equipment on concrete bases. Cast-in-place concrete is specified in Division 3.
2. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Maintain minimum workspace according to manufacturer's written instructions.
4. Connect remote monitoring communication module to electrical power monitoring and control data network through appropriate network interface unit.
5. Identify components according to Division 26 Section "Identification For Electrical Systems".

#### B. Field Quality Control

1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
2. Perform tests and inspections.
3. Tests and Inspections: Perform each visual and mechanical inspection and electrical test stated in the following Sections, except optional tests, in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - a. Current Transformers.
  - b. Capacitors and Reactors, Capacitors.

#### C. Startup Service

1. Perform startup service.
  - a. Complete installation and startup checks according to manufacturer's written instructions.
  - b. Connect and run installed motors and equipment to verify the automatic switching of the capacitors. Verification shall include automatic switching of the total capacity of installed capacitors.
    - 1) Provide sufficient inductive/reactive load banks, in combination with resistive load banks, for the test.

#### D. Demonstration

1. Train Owner's maintenance personnel to adjust, operate, and maintain automatic power factor correction units.

END OF SECTION 26 35 33 16



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Task	Specification	Specification Description
26 35 33 16	26 09 23 00b	Electrical Power Monitoring And Control
26 35 53 00	26 32 13 13	Packaged Engine Generators

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## SECTION 26 36 13 00 - TRANSFER SWITCHES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for transfer switches. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes transfer switches rated 600 V and less, including the following:
  - a. Automatic transfer switches.
  - b. Bypass/isolation switches.
  - c. Nonautomatic transfer switches.
  - d. Remote annunciation systems.
  - e. Remote annunciation and control systems.

#### C. Submittals

1. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.
2. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
3. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems". Include the following:
4. Field quality-control test reports.
5. Operation and maintenance data.

#### D. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
2. Comply with NEMA ICS 1.
3. Comply with NFPA 70.
4. Comply with NFPA 99.
5. Comply with NFPA 110.
6. Comply with UL 1008 unless requirements of these Specifications are stricter.

### 1.2 PRODUCTS

#### A. General Transfer-Switch Product Requirements

1. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.
2. Tested Fault-Current Closing and Withstand Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
  - a. Where transfer switch includes internal fault-current protection, rating of switch and trip unit combination shall exceed indicated fault-current value at installation location.
3. Solid-State Controls: Repetitive accuracy of all settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.



4. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.41. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.
5. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism, mechanically and electrically interlocked in both directions.
6. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
  - a. Limitation: Switches using molded-case switches or circuit breakers or insulated-case circuit-breaker components are not acceptable.
  - b. Switch Action: Double throw; mechanically held in both directions.
  - c. Contacts: Silver composition or silver alloy for load-current switching. Conventional automatic transfer-switch units, rated 225 A and higher, shall have separate arcing contacts.
7. Neutral Switching. Where four-pole switches are indicated, provide neutral pole switched simultaneously with phase poles **OR** overlapping neutral contacts, **as directed**.
8. Neutral Terminal: Solid and fully rated, unless otherwise indicated.
9. Oversize Neutral: Ampacity and switch rating of neutral path through units indicated for oversize neutral shall be double the nominal rating of circuit in which switch is installed.
10. Heater: Equip switches exposed to outdoor temperatures and humidity, and other units indicated, with an internal heater. Provide thermostat within enclosure to control heater.
11. Battery Charger: For generator starting batteries.
  - a. Float type rated 2 **OR** 10, **as directed**, A.
  - b. Ammeter to display charging current.
  - c. Fused ac inputs and dc outputs.
12. Annunciation, Control, and Programming Interface Components: Devices at transfer switches for communicating with remote programming devices, annunciators, or annunciator and control panels shall have communication capability matched with remote device.
13. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, either by color-code or by numbered or lettered wire and cable tape markers at terminations. Color-coding and wire and cable tape markers are specified in Division 26 Section "Identification For Electrical Systems".
  - a. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
  - b. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
  - c. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
14. Enclosures: General-purpose NEMA 250, Type 1 **OR** 3R **OR** 12, **as directed**, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

#### B. Automatic Transfer Switches

1. Comply with Level 1 equipment according to NFPA 110.
2. Switching Arrangement: Double-throw type, incapable of pauses or intermediate position stops during normal functioning, unless otherwise indicated.
3. Manual Switch Operation: Under load, with door closed and with either or both sources energized. Transfer time is same as for electrical operation. Control circuit automatically disconnects from electrical operator during manual operation.
4. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.
5. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval is adjustable from 1 to 30 seconds.
6. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.
7. Transfer Switches Based on Molded-Case-Switch Components: Comply with NEMA AB 1, UL 489, and UL 869A.
8. Automatic Closed-Transition Transfer Switches: Include the following functions and characteristics:

- a. Fully automatic make-before-break operation.
- b. Load transfer without interruption, through momentary interconnection of both power sources not exceeding 100 ms.
- c. Initiation of No-Interruption Transfer: Controlled by in-phase monitor and sensors confirming both sources are present and acceptable.
  - 1) Initiation occurs without active control of generator.
  - 2) Controls ensure that closed-transition load transfer closure occurs only when the 2 sources are within plus or minus 5 electrical degrees maximum, and plus or minus 5 percent maximum voltage difference.
- d. Failure of power source serving load initiates automatic break-before-make transfer.
9. In-Phase Monitor: Factory-wired, internal relay controls transfer so it occurs only when the two sources are synchronized in phase. Relay compares phase relationship and frequency difference between normal and emergency sources and initiates transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer is initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
10. Motor Disconnect and Timing Relay: Controls designate starters so they disconnect motors before transfer and reconnect them selectively at an adjustable time interval after transfer. Control connection to motor starters is through wiring external to automatic transfer switch. Time delay for reconnecting individual motor loads is adjustable between 1 and 60 seconds, and settings are as indicated. Relay contacts handling motor-control circuit inrush and seal currents are rated for actual currents to be encountered.
11. Programmed Neutral Switch Position: Switch operator has a programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Pause is adjustable from 0.5 to 30 seconds minimum and factory set for 0.5 second, unless otherwise indicated. Time delay occurs for both transfer directions. Pause is disabled unless both sources are live.
12. Automatic Transfer-Switch Features:
  - a. Undervoltage Sensing for Each Phase of Normal Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage is adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
  - b. Adjustable Time Delay: For override of normal-source voltage sensing to delay transfer and engine start signals. Adjustable from zero to six seconds, and factory set for one second.
  - c. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
  - d. Time Delay for Retransfer to Normal Source: Adjustable from 0 to 30 minutes, and factory set for 10 minutes to automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
  - e. Test Switch: Simulate normal-source failure.
  - f. Switch-Position Pilot Lights: Indicate source to which load is connected.
  - g. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.
    - 1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    - 2) Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."
  - h. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
  - i. Transfer Override Switch: Overrides automatic retransfer control so automatic transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.



- j. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
- k. Engine Shutdown Contacts: Instantaneous; shall initiate shutdown sequence at remote engine-generator controls after retransfer of load to normal source.
- l. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
- m. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods are adjustable from 10 to 30 minutes. Factory settings are for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:
  - 1) Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
  - 2) Push-button programming control with digital display of settings.
  - 3) Integral battery operation of time switch when normal control power is not available.

#### C. Bypass/Isolation Switches

- 1. Comply with requirements for Level 1 equipment according to NFPA 110.
- 2. Description: Manual type, arranged to select and connect either source of power directly to load, isolating transfer switch from load and from both power sources. Include the following features for each combined automatic transfer switch and bypass/isolation switch:
  - a. Means to lock bypass/isolation switch in the position that isolates transfer switch with an arrangement that permits complete electrical testing of transfer switch while isolated. While isolated, interlocks prevent transfer-switch operation, except for testing or maintenance.
  - b. Drawout Arrangement for Transfer Switch: Provide physical separation from live parts and accessibility for testing and maintenance operations.
  - c. Bypass/Isolation Switch Current, Voltage, Closing, and Short-Circuit Withstand Ratings: Equal to or greater than those of associated automatic transfer switch, and with same phase arrangement and number of poles.
  - d. Contact temperatures of bypass/isolation switches shall not exceed those of automatic transfer-switch contacts when they are carrying rated load.
  - e. Operability: Constructed so load bypass and transfer-switch isolation can be performed by 1 person in no more than 2 operations in 15 seconds or less.
  - f. Legend: Manufacturer's standard legend for control labels and instruction signs shall describe operating instructions.
  - g. Maintainability: Fabricate to allow convenient removal of major components from front without removing other parts or main power conductors.
- 3. Interconnection of Bypass/Isolation Switches with Automatic Transfer Switches: Factory-installed copper bus bars; plated at connection points and braced for the indicated available short-circuit current.

#### D. Nonautomatic Transfer Switches

- 1. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." Switch shall be capable of transferring load in either direction with either or both sources energized.
- 2. Operation: Electrically actuated by push buttons designated "Normal Source" and "Alternate Source." In addition, removable manual handle provides quick-make, quick-break manual-switching action. Switch shall be capable of electrically or manually transferring load in either direction with either or both sources energized. Control circuit disconnects from electrical operator during manual operation.
- 3. Double-Throw Switching Arrangement: Incapable of pauses or intermediate position stops during switching sequence.

4. Nonautomatic Transfer-Switch Accessories:
  - a. Pilot Lights: Indicate source to which load is connected.
  - b. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and alternate-source sensing circuits.
    - 1) Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    - 2) Emergency Power Supervision: Red light with nameplate engraved "Alternate Source Available."
  - c. Unassigned Auxiliary Contacts: One set of normally closed contacts for each switch position, rated 10 A at 240-V ac.
- E. Remote Annunciator System
  1. Functional Description: Remote annunciator panel shall annunciate conditions for indicated transfer switches. Annunciation shall include the following:
    - a. Sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
    - b. Switch position.
    - c. Switch in test mode.
    - d. Failure of communication link.
  2. Annunciator Panel: LED-lamp type with audible signal and silencing switch.
    - a. Indicating Lights: Grouped for each transfer switch monitored.
    - b. Label each group, indicating transfer switch it monitors, location of switch, and identity of load it serves.
    - c. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
    - d. Lamp Test: Push-to-test or lamp-test switch on front panel.
- F. Remote Annunciator And Control System
  1. Functional Description: Include the following functions for indicated transfer switches:
    - a. Indication of sources available, as defined by actual pickup and dropout settings of transfer-switch controls.
    - b. Indication of switch position.
    - c. Indication of switch in test mode.
    - d. Indication of failure of digital communication link.
    - e. Key-switch or user-code access to control functions of panel.
    - f. Control of switch-test initiation.
    - g. Control of switch operation in either direction.
    - h. Control of time-delay bypass for transfer to normal source.
  2. Malfunction of annunciator, annunciation and control panel, or communication link shall not affect functions of automatic transfer switch. In the event of failure of communication link, automatic transfer switch automatically reverts to stand-alone, self-contained operation. Automatic transfer-switch sensing, controlling, or operating function shall not depend on remote panel for proper operation.
  3. Remote Annunciation and Control Panel: Solid-state components. Include the following features:
    - a. Controls and indicating lights grouped together for each transfer switch.
    - b. Label each indicating light control group. Indicate transfer switch it controls, location of switch, and load it serves.
    - c. Digital Communication Capability: Matched to that of transfer switches supervised.
    - d. Mounting: Flush, modular, steel cabinet, unless otherwise indicated.
- G. Source Quality Control
  1. Factory test and inspect components, assembled switches, and associated equipment. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.



### 1.3 EXECUTION

#### A. Installation

1. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Hangers And Supports For Electrical Systems".
2. Floor-Mounting Switch: Anchor to floor by bolting.
  - a. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers And Supports For Electrical Systems".
3. Annunciator and Control Panel Mounting: Flush in wall, unless otherwise indicated.
4. Identify components according to Division 26 Section "Identification For Electrical Systems".
5. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

#### B. Connections

1. Wiring to Remote Components: Match type and number of cables and conductors to control and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to the Owner if necessary to accommodate required wiring.
2. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".
3. Connect wiring according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables".

#### C. Field Quality Control

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.
2. Perform tests and inspections and prepare test reports.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
  - b. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
  - c. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
  - d. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
    - 1) Check for electrical continuity of circuits and for short circuits.
    - 2) Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
    - 3) Verify that manual transfer warnings are properly placed.
    - 4) Perform manual transfer operation.
  - e. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
    - 1) Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
    - 2) Simulate loss of phase-to-ground voltage for each phase of normal source.
    - 3) Verify time-delay settings.
    - 4) Verify pickup and dropout voltages by data readout or inspection of control settings.
    - 5) Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.

- 6) Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.
- f. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
  - 1) Verify grounding connections and locations and ratings of sensors.
3. Coordinate tests with tests of generator and run them concurrently.
4. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.
5. Remove and replace malfunctioning units and retest as specified above.
6. Infrared Scanning: After Final Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.
  - a. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switch 11 months after date of Final Completion.
  - b. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
  - c. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.
- D. Demonstration
  1. Engage a factory-authorized service representative to train the Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment as specified below.
  2. Coordinate this training with that for generator equipment.

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Task	Specification	Specification Description
26 36 13 00	26 24 13 00a	Enclosed Switches And Circuit Breakers
26 36 23 00	26 24 13 00a	Enclosed Switches And Circuit Breakers
26 36 23 00	26 36 13 00	Transfer Switches
26 41 13 13	26 05 26 00	Lightning Protection

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## SECTION 26 43 13 00 - TRANSIENT VOLTAGE SUPPRESSION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for transient voltage suppression. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes field-mounted TVSS for low-voltage (120 to 600 V) power distribution and control equipment.

#### C. Definitions

1. ATS: Acceptance Testing Specifications.
2. SVR: Suppressed voltage rating.
3. TVSS: Transient voltage surge suppressor(s), both singular and plural; also, transient voltage surge suppression.

#### D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating weights, electrical characteristics, furnished specialties, and accessories.
2. Field quality-control reports.
3. Operation and maintenance data.
4. Warranties: Sample of special warranties.

#### E. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency, and marked for intended location and application.
2. Comply with IEEE C62.41.2 and test devices according to IEEE C62.45.
3. Comply with NEMA LS 1.
4. Comply with UL 1283, **as directed**, and UL 1449.
5. Comply with NFPA 70.

#### F. Project Conditions

1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
  - a. Notify Owner no fewer than two days in advance of proposed electrical service interruptions.
  - b. Do not proceed with interruption of electrical service without Owner's written permission.
2. Service Conditions: Rate TVSS devices for continuous operation under the following conditions unless otherwise indicated:
  - a. Maximum Continuous Operating Voltage: Not less than 115 percent of nominal system operating voltage.
  - b. Operating Temperature: **30 to 120 deg F (0 to 50 deg C)**.
  - c. Humidity: 0 to 85 percent, noncondensing.
  - d. Altitude: Less than **20,000 feet (6090 m)** above sea level.

#### G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of surge suppressors that fail in materials or workmanship within Five years from date of Final Completion.



2. Special Warranty for Cord-Connected, Plug-in Surge Suppressors: Manufacturer's standard form in which manufacturer agrees to repair or replace electronic equipment connected to circuits protected by surge suppressors.

## 1.2 PRODUCTS

### A. Service Entrance Suppressors

#### 1. Surge Protection Devices:

- a. Non-modular.
- b. LED indicator lights for power and protection status.
- c. Audible alarm, with silencing switch, to indicate when protection has failed.
- d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

#### OR

#### Surge Protection Devices:

- e. Comply with UL 1449.
- f. Modular design (with field-replaceable modules) **OR** Non-modular design, **as directed**.
- g. Fuses, rated at 200-kA interrupting capacity.
- h. Fabrication using bolted compression lugs for internal wiring.
- i. Integral disconnect switch (if a fused switch or circuit breaker is not provided for the TVSS in the panelboard and the TVSS will not have a direct bus bar connection).
- j. Redundant suppression circuits.
- k. Redundant replaceable modules.
- l. Arrangement with copper bus bars and for bolted connections to phase buses, neutral bus, and ground bus.

#### OR

Arrangement with wire connections to phase buses, neutral bus, and ground bus.

- m. LED indicator lights for power and protection status.
- n. Audible alarm, with silencing switch, to indicate when protection has failed.
- o. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
- p. Four **OR** Six, **as directed**, -digit transient-event counter set to totalize transient surges.
2. Peak Single-Impulse Surge Current Rating: 320 kA per mode/640 kA **OR** 240 kA per mode/480 kA **OR** 160 kA per mode/320 kA, **as directed**, per phase.
3. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2
  - a. Line to Neutral: 70,000 A.
  - b. Line to Ground: 70,000 A.
  - c. Neutral to Ground: 50,000 A.
4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V **OR** 208Y/120 V **OR** 600Y/347 V, **as directed**, 3-phase, 4-wire circuits shall be as follows:
  - a. Line to Neutral: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
  - b. Line to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
  - c. Neutral to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.

#### OR

Protection modes and UL 1449 SVR for 240/120 V, single-phase, 3-wire circuits shall be as follows:

- a. Line to Neutral: 400 V.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

**OR**

Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:

- a. Line to Neutral: 400 V, 800 V from high leg.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

**OR**

Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

- a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- b. Line to Ground: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.

**B. Panelboard Suppressors**

**1. Surge Protection Devices:**

- a. Non-modular.
- b. LED indicator lights for power and protection status.
- c. Audible alarm, with silencing switch, to indicate when protection has failed.
- d. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.

**OR**

Surge Protection Devices:

- a. Comply with UL 1449.
  - b. Modular design (with field-replaceable modules) **OR** Non-modular design, **as directed**.
  - c. Short-circuit current rating complying with UL 1449, and matching or exceeding the panelboard short-circuit rating and redundant suppression circuits; with individually fused metal-oxide varistors.
  - d. Fuses, rated at 200-kA interrupting capacity.
  - e. Fabrication using bolted compression lugs for internal wiring.
  - f. Integral disconnect switch (if a fused switch or circuit breaker is not provided for the TVSS in the panelboard and the TVSS will not have a direct bus bar connection).
  - g. Redundant suppression circuits.
  - h. Redundant replaceable modules.
  - i. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
  - j. LED indicator lights for power and protection status.
  - k. Audible alarm, with silencing switch, to indicate when protection has failed.
  - l. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of protection status. Contacts shall reverse on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
  - m. Four **OR** Six, **as directed**, -digit transient-event counter set to totalize transient surges.
- 2. Peak Single-Impulse Surge Current Rating:** 160 kA per mode/320 kA **OR** 120 kA per mode/240 kA **OR** 80 kA per mode/160 kA, **as directed**, per phase.
- 3. Minimum single impulse current ratings, using 8-by-20-mic.sec waveform described in IEEE C62.41.2:**
- a. Line to Neutral: 70,000 A.
  - b. Line to Ground: 70,000 A.
  - c. Neutral to Ground: 50,000 A.
- 4. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277 V **OR** 208Y/120 V **OR** 600Y/347 V, **as directed**, 3-phase, 4-wire circuits shall be as follows:**
- a. Line to Neutral: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.





- b. Line to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.
- c. Neutral to Ground: 800 V for 480Y/277 V **OR** 400 V for 208Y/120 V **OR** 1200 V for 600Y/347 V, **as directed**.

**OR**

Protection modes and UL 1449 SVR for 240/120-V, single-phase, 3-wire circuits shall be as follows:

- a. Line to Neutral: 400 V.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

**OR**

Protection modes and UL 1449 SVR for 240/120-V, 3-phase, 4-wire circuits with high leg shall be as follows:

- a. Line to Neutral: 400 V, 800 V from high leg.
- b. Line to Ground: 400 V.
- c. Neutral to Ground: 400 V.

**OR**

Protection modes and UL 1449 SVR for 240 V, 480 V, or 600 V, 3-phase, 3-wire, delta circuits shall be as follows:

- a. Line to Line: 2000 V for 480 V **OR** 1000 V for 240 V **OR** 2500 V for 600 V, **as directed**.
- b. Line to Ground: 1500 V for 480 V **OR** 800 V for 240 V **OR** 2500 V for 600 V, **as directed**.

## C. Enclosures

- 1. Indoor Enclosures: NEMA 250 Type 1 **OR** Type 12, **as directed**.
- 2. Outdoor Enclosures: NEMA 250 Type 3R **OR** Type 4 **OR** Type 4X, **as directed**.

## 1.3 EXECUTION

## A. Installation

- 1. Install TVSS devices at service entrance on load side, with ground lead bonded to service entrance ground.
- 2. Install TVSS devices for panelboards and auxiliary panels with conductors or buses between suppressor and points of attachment as short and straight as possible. Do not exceed manufacturer's recommended lead length. Do not bond neutral and ground.
  - a. Provide multiple, 30 **OR** 60 **OR** 100, **as directed**, -A circuit breaker as a dedicated disconnecting means for TVSS unless otherwise indicated.

## B. Field Quality Control

- 1. Perform tests and inspections.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- 2. Tests and Inspections:
  - a. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, "Surge Arresters, Low-Voltage Surge Protection Devices" Section. Certify compliance with test parameters.
  - b. After installing TVSS devices but before electrical circuitry has been energized, test for compliance with requirements.
  - c. Complete startup checks according to manufacturer's written instructions.
- 3. TVSS device will be considered defective if it does not pass tests and inspections.
- 4. Prepare test and inspection reports.

## C. Startup Service

- a. Do not energize or connect service entrance equipment **OR** panelboards **OR** control terminals **OR** data terminals, **as directed**, to their sources until TVSS devices are installed and connected.
- b. Do not perform insulation resistance tests of the distribution wiring equipment with the TVSS installed. Disconnect before conducting insulation resistance tests, and reconnect immediately after the testing is over.

D. Demonstration

- a. Train Owner's maintenance personnel to maintain TVSS devices.

END OF SECTION 26 43 13 00

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Task	Specification	Specification Description
26 51 13 00	02 84 16 00a	Interior Lighting
26 51 16 00	02 84 16 00a	Interior Lighting
26 51 19 00	02 84 16 00a	Interior Lighting
26 51 23 00	02 84 16 00a	Interior Lighting
26 51 33 00	02 84 16 00	Removal of Fluorescent Light Ballasts/Capacitors and Fluorescent Light Tubes
26 51 33 00	02 84 16 00a	Interior Lighting
26 51 33 00	02 84 16 00b	Exterior Lighting
26 52 13 16	02 84 16 00a	Interior Lighting
26 55 13 00	01 22 16 00	No Specification Required
26 55 13 00	02 84 16 00b	Exterior Lighting
26 55 16 00	02 84 16 00a	Interior Lighting
26 55 16 00	02 84 16 00b	Exterior Lighting
26 55 29 00	02 84 16 00b	Exterior Lighting
26 55 53 11	02 84 16 00b	Exterior Lighting

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## SECTION 26 55 61 00 - STAGE LIGHTING

### 1.1 GENERAL

- A. Description Of Work
  - 1. This specification covers the furnishing and installation of materials for stage lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.
- B. Summary
  - 1. Section Includes:
    - a. Dimmer racks.
    - b. Control console and control devices.
    - c. Lighting fixtures and accessories.
    - d. Distribution components.
- C. Performance Requirements
  - 1. Seismic Performance: Dimmer racks shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
    - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed**.
- D. Submittals
  - 1. Product Data: For each type of product indicated.
  - 2. Seismic Qualification Certificates: For **<Insert equipment,>** accessories, and components, from manufacturer.
  - 3. Field quality-control reports.
  - 4. Operation and maintenance data.
  - 5. Software and Firmware Operational Documentation.
- E. Quality Assurance
  - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  - 2. Comply with NECA 1.
  - 3. Comply with NFPA 70.
- F. Software Service Agreement (if allowed)
  - 1. Technical Support: Beginning with Final Completion, provide software support for two years.
  - 2. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
    - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

### 1.2 PRODUCTS

- A. Plug Connectors
  - 1. Pin Type: USITT S3, two-pole, three-wire, 20-A.
  - 2. Twist-Locking Type: NEMA WD 6, two-pole, three-wire, 20-A.



## B. Lighting Fixtures And Accessories

### 1. General:

- a. Comply with UL 1573 and listed and labeled by an NRTL.
- b. Fixtures: Equipped with pigtail, yoke with pipe clamp, safety cable for batten mounting, and filter holder.
- c. Metal Parts: Free of burrs, sharp corners, and edges.
- d. Sheet Metal Components: Steel unless otherwise indicated. Form and support to prevent warping and sagging.
- e. Fixture Doors and Their Internal Access: Smooth operating, free of light leakage under operating conditions, and arranged to permit relamping without use of tools. Doors, lenses, diffusers, and other pieces arranged to prevent accidental falling during relamping and when secured in operating position.
- f. Pigtail: Factory wired, **36-inch- (900-mm-)** long, three-wire cord and plug connector assembly with cord encased in woven fiberglass or silicone tubing.
- g. Lamp Sockets: Relampable without disturbing alignment or focus adjustment.
- h. Fixture Ventilation Openings: Baffled against light leaks.
- i. Fixture Operating Controls and Handles: Thermally insulated.
- j. Lenses: Borosilicate glass in silicone mountings.
- k. Framing Shutters: Stainless steel, four way; with each blade in a separate plane under adjustable tension mounting. Blades adjust plus or minus 30 degrees of rotation in gate, for 120-degree-minimum total angular rotation between adjacent blades.
- l. Color Filter Frame Holder: Attached to front of fixture.
- m. Fixture Yoke: Rigid metal, arranged for vertical aiming of unit and equipped with T-bolt or hand screw to lock alignment.

### 2. Ellipsoidal Spotlights: Fixtures with an elliptical reflector mounted in a fixed relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.

#### a. Tag: ES-1:

- 1) Lamp: 1000 W Q1000/4CL, ANSI FEL.
- 2) Pattern Holders: Three for each fixture, with framing shutters.
- 3) Color Frame: Black, metal.
- 4) Minimum Cosine Illumination Performance Ratings When Operated with ANSI C78 Series, FEL Lamp:
  - a) 171,000 beam candlepower at 20-degree field angle.
  - b) 48,000 beam candlepower at 40-degree field angle.

### 3. Zoom Ellipsoidal Spotlights: Fixtures with an elliptical reflector mounted in an adjustable relationship to the lamp. Light shall be projected through a gate where the beam is shaped by using shutters, a gobo, or an iris. The shaped beam shall then be focused by a system of lenses.

#### a. Tag: ZES-1:

- 1) Lamp: 1000 W Q1000/4CL, ANSI FEL.
- 2) Pattern Holders: Three for each fixture, with framing shutters.
- 3) Operator adjustable from 25- to 50-degree field angle.
- 4) Field-angle adjustment scale label on instrument housing for field reference.
- 5) Minimum Cosine Illumination Performance Rating When Operated with ANSI C78 Series, FEL Lamp: 82,000 beam candlepower at 35-degree field angle.

### 4. Fresnel Lens Spotlights:

#### a. Die-cast extruded-aluminum housing, with hinged front for relamping.

#### b. Tag: FLS-1.

- 1) Lamp: 1000 W Q1000T7/4CL, ANSI EGT.
- 2) Lens: **6 inches (152 mm)**.
- 3) Illumination Performance Rating When Operated with ANSI C78 Series, EGT Lamp:
  - a) 175,000 beam candlepower at 12.5-degree field angle in spot focus.
  - b) 12,000 beam candlepower at 74.6-degree field angle in flood focus.
- 4) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.

### 5. Follow Spotlights:

- a. Tag: FS-1:
  - 1) Lamp: Metal halide, G22 medium bi-post, CRI: 90, color: 6000 K, life: 750 hours, HMI 575 W/GS 95 V.
  - 2) Adjustable lenses in metal housing.
  - 3) Lamp: Quartz-projector type, Adjustable, underslung base stand mounted on **3-inch (75-mm)**, locking-type, rubber-tired, ball-bearing casters.
  - 4) Adjustable lamp holder and socket assembly with precision tuning adjustment; relampable without tools.
  - 5) Three-leaf, full-range mechanical dimmer.
  - 6) Adjustable iris and framing shutters.
  - 7) Automatic color boom.
  - 8) Removable power cable, **25 feet (8 m)** long.
  - 9) Iris Open, Spot-Focus Performance: 800,000, **as directed**, beam candlepower at 7.2, **as directed**, -degree field angle.
  - 10) Iris Open, Flood-Focus Performance: 330,000, **as directed**, beam candlepower at 12.2, **as directed**, -degree field angle.
6. PAR Lamp Holders:
  - a. Tag: PLH-1:
    - 1) Lamp: 300 W PAR 38.
    - 2) Housing: Steel or aluminum, flat black color, **as directed**, with porcelain-plated shell socket.
    - 3) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
  - b. Tag: **<Insert drawing designation>**.
    - 1) Lamp: 575 W tungsten halogen, 90 GLA 575 W, 230 V, color: 3200 K, ANSI GKV.
    - 2) Housing: Steel or aluminum, with porcelain-plated shell socket and color frame, **as directed**.
    - 3) Barn Doors: Two 4-leaf rotatable metal flaps for every three fixtures.
    - 4) With Lens Holder and Replaceable Lenses:
      - a) **<Insert drawing designation>**: Very narrow spot.
      - b) **<Insert drawing designation>**: Narrow spot.
      - c) **<Insert drawing designation>**: Medium flood.
      - d) **<Insert drawing designation>**: Wide flood.
      - e) **<Insert drawing designation>**: Very wide.
    - 5) Motorized **OR** Manual, **as directed**, color wheel.
7. Borderlight Units: Compartmented, three-circuit striplight with nine 150-W, PAR 38/SP **OR** 150-W, PAR 38/FL **OR** 250-W, PAR 38/SP **OR** 150-W, R40/FL, **as directed**, lamps in porcelain sockets and steel sheet housing, **90 inches (2286 mm)** long. Compartments shall be in line and wired on two **OR** three **OR** four, **as directed**, alternate circuits, each producing a different color.
  - a. Front Door: Spring loaded; designed to hold either filter frames or color roundels.
  - b. Color Roundels: One for each lamp; alternating red, blue, and clear, **as directed**.
    - 1) Additional Roundels: **<Insert number>** amber and **<Insert number>** green.
  - c. Hanger: Adjustable, steel-strap type equipped at each end with pipe clamp and safety cable for suspension from a batten.
8. Cyclorama Lights: Suitable for lighting cycloramas from above.
  - a. Tag: CL-1:
    - 1) Lamp: 1000 W Q1000T3/1CL, ANSI FFT.
    - 2) Housing: Aluminum or steel, **as directed**, flat black color, **as directed**, with color frame, **as directed**.
9. Black Lights: Portable, producing a wash of UV light for special effects.
  - a. Tag: BL-1:
    - 1) Lamp: 250 W blacklight flood, H37KB-250, with integral filter to eliminate far-UV effect while maximizing the near-UV effect.
    - 2) Housing: Steel or aluminum, **as directed**, flat black color, **as directed**, with carry handle.
    - 3) C-clamp for using on light pipe.
10. Moving Lights:



- a. Tag: ML-1:
  - 1) General: 700-W, 120-V, metal halide, motorized remote-controlled lighting instrument; NRTL listed.
  - 2) Lamp: Short-arc metal halide, 14,500 lumens; color temperature of 5600 K, CRI of 80.
  - 3) Color System: Three-filter CYM (cyan, yellow, magenta) cross-fading mechanism, and 11 standard colors on a fixed wheel.
  - 4) Optics: Zoom optics with continuously variable field angle from 18.5 to 42 degrees, programmable over a timed range of 2 seconds to 20 minutes; with a mechanical iris for beam-size control. Variable beam focus to soften the edges of gobos and light beams. Zoom combined with iris can project a beam with a field angle of 8 degrees.
  - 5) Dimming: Coated glass dimmer wheel, with controls to provide smooth timed fades.
  - 6) Strobe for strobe lighting effects.
  - 7) Gobo: One rotating wheel with five rotatable wheel positions and one open position. One fixed gobo wheel with 11 pattern positions and one open position.
  - 8) Beam Orientation Control: Smooth pan and tilt using a three-phase stepper motor system. Pan, 540 degrees; tilt, 270 degrees at 0.3-degree repeatability on either axis.
  - 9) Control: ANSI E1.11 (USITT DMX512-A) protocol using five pin connectors.

C. Distribution Components

1. Connector Strip: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly.
  - a. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
  - b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
  - c. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.  
**OR**  
Receptacles: Flush mounted in wireway cover.
  - d. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
  - e. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
  - f. Mounting Hardware: Furnished with each unit; permits surface, single-pipe-bracket, or double-pipe-bracket mounting.
  - g. Finish: Semigloss or matte black.
2. Plug-in Boxes: Listed and labeled by an NRTL; factory-wired wireway and receptacle assembly, 24 inches (600 mm) long unless otherwise indicated; with the following features:
  - a. Wireway: Steel or extruded aluminum, with removable cover and nominal cross-section dimensions of 3 by 4-1/2 inches (75 by 115 mm).
  - b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable.
  - c. Receptacles: Pigtail mounted, 18 inches (450 mm) long, with strain relief at wireway wall penetration.  
**OR**  
Receptacles: Flush mounted in wireway cover.
  - d. Receptacle Wiring: For connecting to terminal blocks; with 125 deg C, crosslinked, PE-insulated, identification-labeled wire.
  - e. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.
  - f. Surface or Grid Mounting: With accessories for surface mounting or with pipe-mounting accessory bracket.
  - g. Recessed Mounting: With flanged cover suitable for recessed mounting in wall.
  - h. Finish: Semigloss or matte black.
3. Gridiron Junction Boxes: Listed and labeled by an NRTL; factory wired with terminal strips and concentric knockouts on all sides.
  - a. Terminal Blocks: Molded-barrier type with screw lugs to suit supply conductors.

- b. Accessories: Cable clamps, support cradles, and cable strain relief grips for each cable, and brackets for surface or pipe mounting.
    - c. Finish: Semigloss or matte black.
  - 4. Floor Pockets: Listed and labeled by an NRTL; flush-mounted, receptacle outlet assembly.
    - a. Box: **0.0598-inch (1.5-mm)** steel sheet, **10 inches (250 mm)** deep.
    - b. Cover Plate: Steel, cast iron, or cast aluminum with nonskid safety tread surface and self-closing, hinged door with cable notches.
    - c. Barrier for allowing installation of low-voltage control receptacle for console input or handheld remotes.
- D. Wire And Cable
  - 1. Building Wire in Raceways: Comply with requirements specified in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
  - 2. Portable Power Cable: Listed and labeled by an NRTL; flexible stage and lighting power cable; Type SC, SCE, or SCT; 600 V; multiconductor; 60 deg C temperature rating.
  - 3. Ethernet Cabling: Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables".
    - a. For 10/100BaseT, comply with provisions for UTP cable and hardware.
    - b. For 10Base-FL, comply with provisions for 50/125 **OR** 62.5/125, **as directed**, -micrometer, multimode, optical-fiber cable and hardware.
  - 4. ANSI E1.11 (USITT DMX512-A) Control Cabling: Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables".
    - a. Standard Cable: NFPA 70, Type CM **OR** Type CMG, **as directed**.
      - 1) Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, No. 22 AWG **OR** No. 24 AWG, **as directed**, stranded, tinned-copper conductors.
      - 2) PE insulation.
      - 3) Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
      - 4) Outer Shield: 90 percent coverage, tinned-copper braid.
      - 5) Outer Shield Drain Wire: Stranded, tinned copper.
      - 6) PVC jacket.
      - 7) Flame Resistance: Comply with UL 1581.
    - b. Plenum-Rated Cable: NFPA 70, Type CMP.
      - 1) Paired, low-capacitance computer cable for ANSI E1.11 (USITT DMX512-A) applications. Two pairs, twisted, No. 22 AWG **OR** No. 24 AWG, **as directed**, stranded, tinned-copper conductors.
      - 2) Insulation: Foam fluoridated ethylene propylene.
      - 3) Inner Shield: 100 percent coverage, aluminum foil-polyester tape.
      - 4) Outer Shield: 90 percent coverage, tinned-copper braid.
      - 5) Outer Shield Drain Wire: Stranded, tinned copper.
      - 6) Low-smoke PVC jacket.
      - 7) Flame Resistance: Comply with NFPA 262.
  - 5. Low-Voltage Control Cabling:
    - a. Control-Cable Conductors:
      - 1) Class 1 Control Circuits: Stranded copper, Type THHN-THWN, in raceway; complying with UL 83.  
**OR**  
Class 1 Control Circuits: Stranded copper, Type THHN, in raceway; complying with UL 44.
      - 2) Class 2 Control Circuits: Stranded copper, Type THHN-THWN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**; complying with UL 83.  
**OR**  
Class 2 Control Circuits: Stranded copper, Type THHN, in raceway **OR** power-limited cable, concealed in building finishes **OR** power-limited tray cable, in cable tray, **as directed**; complying with UL 44.

- 3) Class 3 Remote-Control and Signal Circuits: Stranded copper, Type TW or Type TF; complying with UL 83.
  - b. Paired Cable: NFPA 70, Type CMG.
    - 1) One pair, twisted, No. 16 AWG, stranded, tinned-copper conductors.
    - 2) PVC insulation.
    - 3) Unshielded.
    - 4) PVC jacket.
    - 5) Flame Resistance: Comply with UL 1581.
  - c. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
    - 1) One pair, twisted, No. 16 AWG, stranded (19x29), tinned-copper conductors.
    - 2) PVC insulation.
    - 3) Unshielded.
    - 4) PVC jacket.
    - 5) Flame Resistance: Comply with NFPA 262.
  - d. Paired Cable: NFPA 70, Type CMG.
    - 1) One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
    - 2) PVC insulation.
    - 3) Unshielded.
    - 4) PVC jacket.
    - 5) Flame Resistance: Comply with UL 1581.
  - e. Plenum-Rated, Paired Cable: NFPA 70, Type CMP.
    - 1) One pair, twisted, No. 18 AWG, stranded (19x30), tinned-copper conductors.
    - 2) Fluorinated ethylene propylene insulation.
    - 3) Unshielded.
    - 4) Plastic jacket.
    - 5) Flame Resistance: Comply with NFPA 262.
- E. Lighting Control System
1. Description: Microprocessor-based modular system consisting of dimmer and control modules operated from remote-control stations and a control console.
    - a. Comply with UL 508.
    - b. Comply with USITT AMX192 **OR** ANSI E1.11 (USITT DMX512-A), **as directed**, for data transmission.
  2. Dimmer Racks: Listed and labeled by an NRTL; dead-front, front-access, wall-mounted **OR** freestanding, **as directed**, rack for mounting modular dimmers; formed-steel or extruded-aluminum structural members; completely enclosed with steel or aluminum panels. Painted with manufacturer's standard corrosion-resistant primer and finish coats, and having the following features:
    - a. Primary Circuit Breaker: Fault-current withstand rating of the rack; not less than 10,000 **OR** 50,000, **as directed**, A, symmetrical.
    - b. Hinged, locking front door, with openings to allow air intake across the face of all dimmer modules.
    - c. Individual rack sections shall not exceed **84 inches high by 25 inches deep by 30 inches wide** (2134 mm high by 635 mm deep by 762 mm wide). Multisection racks shall be interconnected with busbars.
    - d. For each module position, provide support rails and control-pin configurations, constructed for precise alignment of dimmer modules into power and signal connector sockets.
    - e. Forced-air cooling of each rack for maintaining operating temperature at each dimmer, assuming full load, in ambient temperature not to exceed 40 deg C. Exhaust rates shall be variable, using temperature sensors and fan-speed control electronics. Individual control of multiple fans is acceptable in lieu of fan-speed control. Fan(s) shall start and stop automatically. Fan noise at full load shall be less than 3.1 sones.
    - f. Each rack shall have an automatic air-temperature sensor to shut off all dimmers in the rack should the internal temperature rise above maximum safe operating limits. In an

- overheat condition, the fan shall continue operating. When a safe operating temperature is restored, the system shall automatically reset to allow normal user control.
- g. Fabricate and test dimmer racks to withstand seismic forces defined in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Dimmers: Modular solid-state units that operate smoothly over their operating ranges without audible lamp noise or radio-frequency interference at any setting. Modules shall be dead-front, draw-out type with floating line, load, and control sockets for smooth insertion and withdrawal; with load-side thermal-magnetic circuit breaker, speed-controlled cooling fan, and overtemperature sensor.
- a. Non-Dim Units: On-off relay control only. Capable of serving inductive loads such as motors or high-intensity-discharge fixtures.
- b. Surge Protection: Modules shall withstand power-line surges of 6000 V/3000 A according to IEEE C62.41.1 and IEEE C62.41.2.
- c. Filter each dimmed circuit to provide a minimum 350-mic.sec., current-rise time at a 90-degree conduction angle at 50 percent of rated dimmer capacity. At any load within rating, rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load current waveform.
4. Control System: Microprocessor-based control system, ANSI E1.11 (USITT DMX512-A) protocol, with a nonvolatile system memory to adjust dimmer channel settings for different scenes, to patch dimmers to channels, and to manually or automatically change dimmer settings from one preset scene to another.
- a. Control shall support Ethernet-based LAN at every control device.
- b. Provide means to create and monitor show data on a PC using software by console manufacturer. Software shall be capable of the following:
- 1) Creating show and providing for use of USITT show files.
  - 2) Playing back show in a console-simulation mode.
  - 3) Accessing all remote-control stations associated with the console and control system.
  - 4) Providing standard Ethernet connection between the console control system and the PC.
- c. Display the following system status information on a color, 17-inch (430-mm) LCD monitor associated with the control console:
- 1) Current channel intensities.
  - 2) Cue information.
  - 3) Monitor.
- d. Moving Lights: Include a standard control library, a program patch specific to fixture(s) provided, and selective programming with ANSI E1-11 (USITT DMX512-A) addressing of fade, focus points, beam, image, color, <Insert attributes> and position.
5. Control Console: Tabletop unit with manual and computer-based programming controls, memory units, indicating devices, and the following features:
- a. Servicing access through hinged top panel.
- b. Grand-master level control.
- c. Blackout switch.
- d. 12 submaster level controls with overlapping pile-on performance.
- OR**
- 24 submaster level controls with overlapping pile-on performance.
- e. Bump buttons for momentary control of channels or submasters, one for each submaster level control.
- f. Two cross-fade controls for split dipless fade between scenes, each with its own fade progress indicator.
- g. One set of scene level controls for each scene when used in two-scene preset mode. Second set of scene level controls to allow setting levels into memory for expanded single scenes when used in multiple single-channel scene mode. Each set shall have same quantity of scene level controls as is used for submaster level controls.
- h. Multibutton keypad for programming in multiscene memory mode.

- i. Fade time control for assigning fade time to cues, with individual cue adjustment from one second to five minutes, minimum.
  - j. Light-emitting diode **OR** LCD **OR** Computer monitor cathode-ray tube, **as directed**, with associated display controls, for displaying operating menus and memory readout.
  - k. Controls for setting levels into memory.
  - l. Cord and connector for connecting console to outlets for console power and control.
6. System Operation: Selectable between multichannel two-scene preset and four-channel single-scene memory. Console features include electronic patching of control signals for up to 512 dimmers and off-line data storage using internal, **3-1/2-inch (90-mm)** disk-drive unit. Operational capability includes the following:
  - a. Live and blind programming.
  - b. Special effects programmability for automatic operation of lights in pulsating, sequential dimming and brightening, and other special operating modes. Special effects menu displays operator guidance for programming and individual step levels.
  - c. Signal from fire-alarm control panel that automatically brings selected circuits to fully on or fully bright condition, overriding normal dimming and on-off controls.
  - d. Inserting cues between designated cues without renumbering.
  - e. Out-of-sequence playback of cues.
  - f. Controlling houselights and stage lights from console by assigning their dimmers or non-dim on-off controls to a channel.
  - g. Retaining programmed cues in memory for minimum of one year after power outage.
  - h. Automatic sequential execution of programmed cues.
  - i. Printing cues using parallel or serial printer port, cable, and printer. Cable and printer are not included with this system.
7. PC: Standard, unmodified, with accessories and peripherals that are configured to install and run control-console manufacturer's written requirements, but not less than the following:
  - a. CPU operating speed shall be at least 1.6 GHz.
  - b. Memory: 1024 MB.
  - c. Serial Ports: Provide two for general use.
  - d. Parallel Port: Enhanced.
  - e. LAN Adapter: 10/100/1000 Mbps, internal network interface card.
  - f. Three USB 2.0 ports.
  - g. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
  - h. Color Monitor: Not less than **17 inches (430 mm)**, with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm. Video card shall support at least 256 colors at a resolution of 1280 by 1024 pixels at a minimum refresh rate of 70 Hz.
  - i. Keyboard: With a minimum of 64 characters; standard ASCII character set based on ANSI INCITS 154 (formerly ANSI X3.154).
  - j. Mouse: Standard, compatible with installed software.
  - k. Disk storage shall include the following, each with appropriate controller:
    - 1) Minimum 60 GB hard disk, 5400 rpm.
    - 2) Floppy Disk Drive: High density, **3-1/2-inch (90-mm)** size.
    - 3) **<Insert disk drives>**.
  - l. CD-ROM Drive: 24x/10x/24x CD-RW/8x DVD combination.
8. Console Power and Control Outlets: Multiple receptacles matched to connector on console connector cord.
9. House Lighting Control Station: Architectural-type, multichannel, remote-dimmer-control station with the following features:
  - a. System controls designated houselights, stage lights, and other lights.
  - b. Stage lighting controls compatible with dimming and control system.
  - c. Flush mounting.
  - d. Brushed-aluminum wall plate.
  - e. Five **OR** Six, **as directed**, channels, each with slider potentiometer control.



- f. Master-slider potentiometer that controls lights on all channels proportionally from completely dimmed to degree of brightness that corresponds to individual slider positions.
- g. Fully on switch that turns all channels on at full brightness regardless of slider position.
- h. Take-control/off switch that places station in control of channels and sets lighting to levels dictated by channel and master-slider controls.
- i. Legend on face of wall plate that identifies items as "House Lighting Control Station" and identifies functions of each slider and switch position, with slider positions individually graduated from zero to 10.
- j. Illuminated push buttons for activating preset scenes of house lighting and labeled "Entry" OR "Panic" OR "Entry" and "Panic," **as directed**.
- k. Flush wall mounted unless otherwise indicated.
- 10. Entry Station: Push button activates or deactivates indicating light and presets scene of house lighting control system.
  - a. Light-emitting-diode indicating light illuminates when preset command is executed.
  - b. Labeled "Entry."
  - c. Flush wall mounted unless otherwise indicated.
- 11. Key-Entry Station: Key-operated switch controls station to activate or deactivate indicating light and presets scene of lighting control system.
  - a. Light-emitting-diode indicating light illuminates when preset command is executed.
  - b. Labeled "Entry."
  - c. Flush wall mounted unless otherwise indicated.
- 12. Emergency Lighting Control Station: Key-operated, **as directed**, push button activates indicating light and brings selected dimmers to fully bright condition, i.e., the "Panic" preset. Operating push button a second time returns dimmers to previous setting.
  - a. Emergency mode indicating light.
  - b. Labeled "Emergency Lights."
  - c. Flush wall mounted unless otherwise indicated.

F. Rigging Components

- 1. Pipe Clamps: Malleable iron, suitable for clamping fixtures or items to pipe from **3/4 to 2 inches (20 to 51 mm)** in OD. Arranged for horizontal rotation of yoke for aiming; equipped with T-bolt to lock alignment.
- 2. Safety Cables: Heavy-duty, flexible steel; **30-inch (762-mm)** nominal length, with spring clip at one end and steel ring at the other end.
- 3. Cable Grips: Stainless **OR** Galvanized, **as directed**, steel; basket-weave type for supporting stage cables.

### 1.3 EXECUTION

A. Installation

- 1. Set permanently mounted items level, plumb, and square with ceilings and walls.
- 2. Indicated mounting heights are to bottom of unit for suspended items and to center of unit for wall-mounted items.
- 3. Mount and connect fixtures, and install and connect distribution devices.
  - a. If arrangement is not indicated, install so each fixture, dimmer, house lighting circuit, control channel, and outlet circuit can be operated, and complete system demonstrated, in all operating modes.
  - b. Install safety cables secured to stage rigging or gridiron for all pipe-mounted electrical fixtures and equipment.
- 4. Dimmer Rack Mounting: Install and anchor dimmer racks level on **4-inch- (100-mm-)** high concrete base. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around full perimeter of base.

- b. For dimmer racks, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - c. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - d. Install anchor bolts to elevations required for proper attachment to dimmer racks.
5. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".

**B. Wiring**

1. Power Wiring:
  - a. Install wiring as specified in Division 26 Section "Low-voltage Electrical Power Conductors And Cables" for hardwired connections. Install wiring in raceways except cable and plug connections.
  - b. Install power wiring with a separate neutral for each output circuit from main dimmer and for each house and stage lighting circuit.
2. Signaling, Remote-Control, and Power-Limited Circuits:
  - a. Comply with requirements specified in Division 26 Section "Control-voltage Electrical Power Cables" for installation of wiring. Install wiring in raceways except cable and plug connections.
  - b. Comply with the following unless otherwise indicated:
    - 1) Size conductors according to lighting control device manufacturer's written instructions.
    - 2) Select cable insulation, shielding, drain wire, and jacket complying with lighting control device manufacturer's written instructions.
    - 3) Install circuits to eliminate radio-frequency interference and electromagnetic interference.
  - c. Remote-control circuits associated with emergency lighting control shall be installed complying with Class 1 Circuit standards in NFPA 70.
3. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points.
4. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes and in terminal cabinets and equipment enclosures.
5. Remove wall plates and protect devices and assemblies during painting.
6. Support lighting fixtures, distribution components, and accessories as specified in Division 26 Section "Hangers And Supports For Electrical Systems". Equip all pipe-mounted equipment with safety cables that are secured to supporting pipe.
7. Ground equipment according to Division 26 Section "Grounding And Bonding For Electrical Systems".

**C. Identification**

1. Identify components, power, and control wiring according to Division 26 Section "Identification For Electrical Systems".
2. Label each fixture, lighting outlet, distribution device, and dimmer module with unique designation. Labels on elevated components shall be readable from the floor.

**D. Field Quality Control**

1. Perform tests and inspections.
2. Tests and Inspections:
  - a. Schedule visual and mechanical inspections and electrical tests with at least seven days' advance notice.
  - b. Visual and Mechanical Tests and Inspections:
    - 1) Inspect each fixture, outlet, module, control, and device for defects, finish failure, corrosion, physical damage, labeling by an NRTL, and nameplate.
    - 2) Exercise and perform operational tests on mechanical parts and operable devices according to manufacturer's written instructions.
    - 3) Check tightness of electrical connections with torque wrench.

- 4) Verify proper protective device settings, fuse types, and ratings.
      - 5) Record results of tests and inspections.
    - c. Electrical Tests: Perform tests according to manufacturer's written instructions.
      - 1) Continuity tests of circuits.
      - 2) Operational Tests: Connect each outlet to a fixture and a dimmer output circuit so each dimmer module, dimmer control and output circuit, outlet, and fixture in a typical operating mode will be sequentially tested. Set and operate controls to demonstrate fixtures, outlets, dimmers, and controls in a sequence that cues and reproduces actual operating functions for a typical system of the size and scope installed. Include operation and control of houselights and stage lights from each control location and station including optional plug-in, control-console outlet locations. Record fixture and outlet assignments, control settings, operations, cues, and observations of performance.
    - d. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible organization and individual.
  3. Stage lighting will be considered defective if it does not pass tests and inspections.
  4. Prepare test and inspection reports.
    - a. Prepare a schedule of lighting outlets by number; indicate circuits, dimmers, connected fixtures, and control-channel assignments. Prepare a schedule of control settings and circuit assignments for house control channels. Prepare written reports of tests and observations. Report defective materials, workmanship, and unsatisfactory test results. Include records of repairs and adjustments made.
- E. Adjusting
1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

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## SECTION 26 55 68 00 - SPORTS LIGHTING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for exterior athletic lighting. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes lighting for the following outdoor sports venues:
  - a. Baseball fields.
  - b. Softball fields.
  - c. Football fields.
  - d. Soccer fields.
  - e. Outdoor tennis courts.

#### C. Definitions

1. CV: Coefficient of variation; a statistical measure of the weighted average of all relevant illumination values for the playing area, expressed as the ratio of the standard deviation for all illuminance values to the mean illuminance value.
2. Delegated-Design Submittals: Documents, including drawings, calculations, and material and product specifications prepared as a responsibility of Contractor to obtain acceptance by the Owner and authorities having jurisdiction.
3. Illuminance: The metric most commonly used to evaluate lighting systems. It is the density of luminous flux, or flow of light, reaching a surface divided by the area of that surface.
  - a. Horizontal Illuminance: Measurement in foot-candles (lux), on a horizontal surface 36 inches (914 mm) above ground unless otherwise indicated.
  - b. Target Illuminance: Average maintained illuminance level, calculated by multiplying initial illuminance by LLF.
  - c. Vertical Illuminance: Measurement in foot-candles (lux), in two **OR** four, **as directed**, directions on a vertical surface, at an elevation coinciding with plane height of horizontal measurements.
4. LC: Lighting Certified.
5. Light Trespass: Light spill into areas and properties outside the playing areas, which is either annoying or unwanted.
6. LLD: Lamp lumen depreciation, which is the decrease in lamp output as the lamp ages.
7. LLF: Light loss factor, which is the product of all factors that contribute to light loss in the system.
8. Luminaire: Complete lighting fixture, including ballast housing if integral.
9. UG: Uniformity gradient; the rate of change of illuminance on the playing field, expressed as a ratio between the illuminances of adjacent measuring points on a uniform grid.

#### D. Performance Requirements

1. Facility Type: Professional **OR** College **OR** Semiprofessional **OR** Sports club **OR** Amateur league **OR** High school **OR** Training facility **OR** Elementary school **OR** Recreational or social facility, **as directed**.
2. Illumination Criteria:
  - a. Minimum average target illuminance level for each lighted area for each sports venue and for the indicated class of play according to IESNA RP-6.
  - b. CV and maximum-to-minimum uniformity ratios for each lighted area equal to or less than those listed in IESNA RP-6 for the indicated class of play.
  - c. UG levels within each lighted area equal to or less than those listed in IESNA RP-6 for the indicated speed of sport.

3. Illumination Criteria:
  - a. Minimum Average Target Illumination: **<Insert value>**.
  - b. CV: **<Insert value>**.
  - c. Maximum-to-Minimum Uniformity Ratio: **<Insert value>**.
  - d. UG Level: **<Insert value>**.
4. Illumination Calculations: Computer-analyzed point method complying with IESNA RP-6 to optimize selection, location, and aiming of luminaires.
  - a. Grid Pattern Dimensions: For playing areas of each sport and areas of concern for spill-light control, correlate and reference calculated parameters to the grid areas. Each grid point represents the center of the grid area defined by the length and width of the grid spacing.
  - b. Spill-Light Control: Minimize spill light for each playing area on adjacent and nearby areas.
    - 1) Prevent light trespass on properties near Project as defined by **<Insert name(s) of authorities having jurisdiction>**.
    - 2) For areas indicated on Drawings as "spill-light critical," limit the level of illuminance directed into the area from any luminaire or group of luminaires, and measured **36 inches (914 mm)** above grade to the following:
      - a) Maximum Horizontal Illuminance: **0.25 fc (2.7 lux) OR 0.5 fc (5.4 lux) OR 0.75 fc (8.1 lux), as directed.**
      - b) Maximum Vertical Illuminance from the Direction of the Greatest Contribution of Light: **1.0 fc (10.8 lux) OR 2.0 fc (21.5 lux) OR 3.0 fc (32.3 lux), as directed.**
    - 3) Calculate the horizontal and vertical illuminance due to spill light for points spaced **20 feet (6 m)** apart in areas indicated on Drawings as "spill-light critical," to ensure that design meets the above limits.
  - c. Glare Control: Design illumination for each playing area to minimize direct glare in adjacent and nearby areas.
    - 1) Design source intensity of luminaires that may be observed at an elevation of **60 inches (1524 mm)** above finished grade from nearby properties to be less than 12,000 **OR 20,000 OR 30,000, as directed**, candela when so observed.
    - 2) Design source intensity of luminaires that may be observed at an elevation of **60 inches (1524 mm)** above finished grade from designated "spill-light critical" areas to be less than 12,000 **OR 20,000 OR 30,000, as directed**, candela when so observed.
  - d. Determine LLF according to IESNA RP-6 and manufacturer's test data.
    - 1) Use LLD at 100 percent of rated lamp life. LLF shall be applied to initial illumination to ensure that target illumination is achieved at 100 percent of lamp life and shall include consideration of field factor.
    - 2) LLF shall not be higher than 70 percent, and may be lower when determined by manufacturer after application of the ballast output and optical system output according to IESNA RP-6.
  - e. Luminaire Mounting Height: Comply with IESNA RP-6, with consideration for requirements to minimize spill light and glare.
  - f. Luminaire Placement: Luminaire clusters shall be outside the glare zones defined by IESNA RP-6.
5. Baseball Fields:
  - a. IESNA RP-6, Class of Play: **I OR II OR III OR IV, as directed.**
  - b. Speed of Sport: **Fast OR Moderate OR Slow, as directed.**
  - c. Grid Pattern Dimensions: **30 by 30 feet (9 by 9 m).**
6. Softball Fields:
  - a. IESNA RP-6, Class of Play: **I OR II OR III OR IV, as directed.**
  - b. Speed of Sport: **Fast OR Moderate OR Slow, as directed.**
  - c. Grid Pattern Dimensions: **20 by 20 feet (6 by 6 m).**
7. Football Fields:
  - a. IESNA RP-6, Class of Play: **I OR II OR III OR IV, as directed.**

- b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
  - c. Grid Pattern Dimensions: **30 by 30 feet (9 by 9 m)**.
8. Soccer Fields:
  - a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.
  - b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
  - c. Grid Pattern Dimensions: **30 by 30 feet (9 by 9 m)**.
9. Outdoor Tennis Courts:
  - a. IESNA RP-6, Class of Play: I **OR** II **OR** III **OR** IV, **as directed**.
  - b. Speed of Sport: Fast **OR** Moderate **OR** Slow, **as directed**.
  - c. Grid Pattern Dimensions: **10 by 10 feet (3 by 3 m)**.
10. Egress Lighting: In case of power failure, provide a minimum of **1.0-fc (10.8-lux)** illumination, within 30 seconds, measured at grade in spectator and spectator egress areas.
  - a. Duration of emergency illumination shall be not less than 15 minutes.
  - b. Momentary Power Interruptions: Provide emergency illumination immediately following restoration of power to the lighting circuits. Emergency illumination shall automatically extinguish after 15 minutes.
11. Lighting Control: Manual, low voltage, or digital; providing the following functions, integrated into a single control station, with multiple subcontrol stations as indicated:
  - a. Control Station: Key-operated master switch, manual push-button controls, and system status indicator lights. Test switch of egress lighting system, **as directed**.
  - b. Light Levels: Two levels of control - 100/50 percent of minimum target illumination.
12. Electric Power Distribution Requirements:
  - a. Electric Power: 208 **OR** 230 **OR** 480, **as directed**, V; three phase.
    - 1) Include roughing-in of service indicated for nonsports improvements on Project site.
    - 2) Balance load between phases. Install wiring to balance three phases at each support structure.
    - 3) Include required overcurrent protective devices and individual lighting control for each sports field or venue.
    - 4) Include indicated feeder capacity and panelboard provisions for future lighted sports field construction.
13. Maximum Total Load: **<Insert number> A**.
  - a. Maximum Total Voltage Drop from Source to Load: 5 percent, including voltage drops in branch circuit, subfeeder, and feeder.
14. Seismic Performance: Luminaires, ballasts, and support structures shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
15. Life-Cycle Cost Criteria:
  - a. Estimated life-cycle cost of lighting system for period of **<Insert number>** years based on the parameters below:
    - 1) Energy Cost: **<Insert value>** {Calculate energy costs by multiplying (number of luminaires) x (kilowatt demand per luminaire) x (power cost at \$/kilowatts) x (number of annual usage hours) x (number of years)}.
    - 2) Lamp Replacement Cost: **<Insert value>** (Calculate replacement costs by multiplying (cost to replace a lamp) x (number of luminaires) x (number of relamps over the period of years used in calculating the energy cost)).
    - 3) General Maintenance: **<Insert value>** (Calculate maintenance costs by multiplying (number of repairs) x (cost per repair) over the life cycle).
  - OR**
  - Life-Cycle Cost Criteria: **<Insert value>** (Calculate according to Federal Energy Management Program's "Building Life-Cycle Cost").

E. Submittals

1. Product Data: For each type of lighting product indicated. Include the following:



- a. Lamp life, output, and energy-efficiency data. Lamp data certified by NVLAP or NRTL; comply with IESNA LM-47.
- b. Photometric data based on laboratory tests of each luminaire type, complete with lamps, ballasts, and accessories; comply with IESNA LM-5.
  - 1) Photometric data shall be certified by a qualified independent testing agency.
  - OR**
  - Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
2. Delegated-Design Submittal: For exterior athletic lighting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Drawings and specifications for construction of lighting system.
  - b. Manufacturer's determination of LLF used in design calculations.
  - c. Lighting system design calculations for the following:
    - 1) Target illuminance.
    - 2) Point calculations of horizontal and vertical illuminance, CV, and UG at minimum grid size and area.
    - 3) Point calculations of horizontal and vertical illuminance in indicated areas of concern for spill light.
    - 4) Calculations of source intensity of luminaires observed at eye level from indicated properties near the playing fields.
  - d. Electrical system design calculations for the following:
    - 1) Short-circuit current calculations for rating of panelboards.
    - 2) Total connected and estimated peak-demand electrical load, in kilowatts, of lighting system.
    - 3) Capacity of feeder **OR** service, **as directed**, required to supply lighting system.
  - e. Wiring requirements, including required conductors and cables and wiring methods.
  - f. Structural analysis data and calculations used for pole selection.
    - 1) Manufacturer Wind-Load Strength Certification: Submit certification that selected total support system, including poles, complies with AASHTO LTS-4-M for location of Project.
3. Qualification Data: For qualified Installer, manufacturer, professional engineer, luminaire photometric data testing laboratory and field testing agency.
4. Seismic Qualification Certificates: For luminaires, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
5. Manufacturer Certificates: For support structures, including brackets, arms, appurtenances, bases, anchorages, and foundations, from manufacturer.
6. Welding certificates.
7. Field quality-control reports.
8. Operation and Maintenance Data: For sports lighting system components to include in emergency, operation, and maintenance manuals.
9. Warranty: Sample of special warranty.
- F. Quality Assurance
  1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
  2. Manufacturer Qualifications: Manufacturer's responsibilities include fabricating sports lighting and providing professional engineering services needed to assume engineering responsibility.

- a. Engineering Responsibility: Preparation of delegated-design submittals and comprehensive engineering analysis by a qualified professional engineer who is additionally LC by the National Council on Qualifications for the Lighting Professions, **as directed**.
  3. Luminaire Photometric Data Testing Laboratory: By manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.
  4. Luminaire Photometric Data Testing Laboratory: By an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL.
  5. Field Testing Agency Qualifications: An independent testing agency that is accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products, or an NRTL as defined in 29 CFR 1910, with the experience and capability to conduct field testing according to IESNA LM-5.  
**OR**  
Field Testing Agency Qualifications: A qualified independent professional engineer not associated with Contractor or lighting equipment manufacturer, who is additionally LC by the National Council on Qualifications for the Lighting Professions, **as directed**.
  6. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel" and AWS D1.2/D1.2M, "Structural Welding Code - Aluminum."
  7. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of luminaires, lamps, and luminaire alignment products and to correct misalignment that occurs subsequent to successful acceptance tests. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, and unauthorized repairs and alterations from special warranty coverage.
    - a. Luminaire Warranty: Luminaire and luminaire assembly (excluding fuses and lamps) shall be free from defects in materials and workmanship for a period of five years from date of Final Completion.
    - b. Lamp Warranty:
      - 1) Replace lamps and fuses that fail within 12 months from date of Final Completion.
      - 2) Provide replacement lamps for lamps that fail within the second 12 months from date of Final Completion.
    - c. Alignment Warranty: Accuracy of alignment of luminaires shall remain within specified illuminance uniformity ratios for a period of five years from date of successful completion of acceptance tests.
      - 1) Realign luminaires that become misaligned during the warranty period.
      - 2) Replace alignment products that fail within the warranty period.
      - 3) Verify successful realignment of luminaires by retesting as specified in "Field Quality Control" Article.

## 1.2 PRODUCTS

- A. Luminaires, Lamps, And Ballasts
1. Luminaires: Listed and labeled, by an NRTL acceptable to authorities having jurisdiction, for compliance with UL 1598 for installation in wet locations.
    - a. Doors, Frames, and Other Internal Access: Smooth operating, free from light leakage under operating conditions, and arranged to permit relamping without using tools. Arrange doors, frames, lenses, diffusers, and other pieces to prevent their accidental falling during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lens.
    - b. Exposed Hardware: Stainless-steel latches, fasteners, and hinges.



- c. Spill-Light Control Devices: Internal louvers and external baffles furnished by manufacturer and designed for secure attachment to specific luminaire.
- d. Luminaires for tennis courts shall be bracket-mounted, full-cutoff type with integral ballasts.
- e. Lamps for Tennis Court Luminaires: Metal halide, rated 1000 W.
- 2. Ballast Mounting: Grouped in cabinets, remote from **OR** At, **as directed**, location of associated luminaires unless otherwise indicated.

#### B. Support Structures

- 1. Support-Structure Wind-Load Strength: Poles and other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall comply with AASHTO LTS-4-M and shall be certified by manufacturers to withstand winds up to **100 mph (160 km/h)** without permanent deflection or whipping.
- 2. Support-Structure Seismic Strength: Poles or other support structures, brackets, arms, appurtenances, bases, anchorages, and foundations shall be designed to prevent separation of components or fracture of poles, luminaire supports, or pole foundations during a seismic event.
- 3. Mountings, Fasteners, and Appurtenances:
  - a. Corrosion resistant, compatible with support components, and which shall not cause galvanic action at contact points.
    - 1) Steel Components: Hot-dip galvanized after fabrication, complying with ASTM A 123/A 123M.
    - 2) Mounting Hardware Fasteners: Hot-dip galvanized, complying with ASTM A 153/A 153M, or minimum 18-8 grade stainless steel.
  - b. Accommodate attachments and wiring of other indicated systems.
- 4. Concrete for Pole Foundations: **3000-psi (20.7-MPa)**, 28-day minimum compressive strength. Concrete, reinforcement, and formwork are specified in Division 03 Section "Cast-in-place Concrete".
- 5. Direct-buried steel structures or poles shall not be used.

#### C. Power Distribution And Control

- 1. Wiring Method for Feeders, Subfeeders, Branch Circuits, and Control Wiring: Underground nonmetallic raceway; No. 10 AWG minimum conductor size for power wiring.
- 2. Overhead-, pole-, or structure-supported wiring and transformers are **OR** are not, **as directed**, permitted.
- 3. Electrical Enclosures Exposed to Weather: NEMA 250, Type 3R enclosure constructed from stainless steel **OR** corrosion-resistant material, **as directed**, with hinged doors fitted with padlock hasps or lockable latches.

#### D. Surge Protection

- 1. Surge Protection: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" and include surge suppressors with the following requirements:
  - a. Panelboard type.
  - b. Nonmodular, with digital indicator lights and one set of dry contacts, **as directed**.
  - c. Peak Single-Impulse Surge Current Rating: **<Insert number> kA** per phase.

#### E. Pole And Base Protection

- 1. Pole Pads: Wraparound pad, with **4 inches (100 mm)** of extra-firm polyfoam, 360-degree coverage of ground-mounted poles and supports, continuous hook-and-loop fastening, and not less than **72 inches (1820 mm)** high.

### 1.3 EXECUTION

#### A. Installation

1. Use web fabric slings (not chain or cable) to raise and set structural members. Protect equipment during installation to prevent corrosion.
  2. Install poles and other structural units level, plumb, and square.
  3. Except for embedded structural members, grout void between pole base and foundation. Use nonshrinking or expanding concrete grout firmly packed in entire void space. Use a short piece of **1/2-inch- (13-mm-)** diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole. Nonshrink grout is specified in Division 05 Section "Metal Fabrications".
  4. Install pole pads at all poles inside playing field boundaries and when located within **20 feet (6 m)** of the field boundary.
  5. Extend cast-in-place bolted base foundations **36 inches (914 mm)** above grade, minimum.
  6. Install protective pipe bollards on two **OR** three, **as directed**, sides of each embedded pole installed in paved areas. See Division 05 Section "Metal Fabrications" for pipe bollards.
  7. Install controls and ballast housings in cabinets mounted on support structure at least **10 feet (3 m)** above finished grade.
- B. Field Quality Control
1. Perform tests, inspections, and analysis according to IESNA RP-6 and IESNA LM-5 where applicable.
  2. Tests and Inspections:
    - a. After installing sports lighting system and after electrical circuits have been energized, perform proof-of-performance field measurements and analysis for compliance with requirements.
    - b. Playing and Other Designated Areas: Make field measurements at intersections of grids, dimensioned and located as specified in "Performance Requirements" Article and as described below:
      - 1) Baseball Fields: Measure at least 25 points of the infield and 87 points of the outfield. Extend the grid **15 feet (5 m)** outside the foul lines, extending to outfield boundary or fence.
      - 2) Softball Fields: Measure at least 16 points of the infield and 48 points of the outfield. Extend the grid **15 feet (5 m)** outside the foul lines, extending to outfield boundary.
      - 3) Football Fields: Lighted area is **180 by 360 feet (55 by 110 m)**. Measure at least 91 points.
      - 4) Soccer Fields: Lighted area is **210 by 370 feet (64 by 113 m)**. Measure at least 91 points.
      - 5) Tennis Courts: Measure at least 30 points for a double court.
    - c. Make field measurements at established test points in areas of concern for spill light and glare.
    - d. Perform analysis to demonstrate correlation of field measurements with specified illumination quality and quantity values and corresponding computer-generated values that were submitted with engineered design documents. Submit a report of the analysis. For computer-generated values, use manufacturer's lamp lumens that are adjusted to lamp age at time of field testing.
  3. Correction of Illumination Deficiencies for Playing Areas: Make corrections to illumination quality or quantity, measured in field quality-control tests, that varies from specified illumination criteria by plus or minus 10 percent.
    - a. Add or replace luminaires, or change mounting height, revise aiming, or install louvers, shields, or baffles.
    - b. If luminaires are added or mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
    - c. Do not replace luminaires with units of higher or lower wattage without the Owner's approval.
    - d. Retest as specified above after repairs, adjustments, or replacements are made.
    - e. Report results in writing.





4. Correction of Excessive Illumination in Spill-Light-Critical Areas: If measurements indicate that specified limits for spill light are exceeded, make corrections to illumination quantity, measured in field quality-control tests, that reduce levels to within specified maximum values.
  - a. Replace luminaires, or change mounting heights, revise aiming, or install louvers, shields, or baffles.
  - b. Obtain the Owner's approval to replace luminaires with units of higher or lower wattage.
  - c. If mounting height is changed, revise aiming and recalculate and modify or replace support structures if indicated.
  - d. Retest as specified above after repairs, adjustments, or replacements are made.
  - e. Report results in writing.
5. Sports lighting will be considered defective if it does not pass tests and inspections.
6. Prepare test and inspection reports.

C. Demonstration

1. Train the Owner's maintenance personnel to adjust, operate, and maintain exterior athletic lighting.

END OF SECTION 26 55 68 00

Task	Specification	Specification Description
26 56 13 00	01 22 16 00	No Specification Required
26 56 13 00	02 84 33 00	Overhead Electrical Distribution
26 56 13 00	02 84 16 00b	Exterior Lighting
26 56 18 00	02 84 16 00b	Exterior Lighting
26 56 19 00	02 84 16 00a	Interior Lighting
26 56 19 00	02 84 16 00b	Exterior Lighting
26 56 21 00	01 22 16 00	No Specification Required
26 56 21 00	02 84 33 00	Overhead Electrical Distribution
26 56 21 00	02 84 16 00b	Exterior Lighting

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Task	Specification	Specification Description
27 05 26 00	26 05 53 00a	Intercommunications and Program Systems
27 11 16 00	26 05 53 00a	Intercommunications and Program Systems

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## SECTION 27 11 19 00 - LOOSE-TUBE GEL-FILLED FIBER OPTIC CABLES

### GENERAL

#### Description Of Work

1. This specification covers the furnishing and installation of loose-tube gel-filled fiber optic cables. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### Shop Drawings And Samples

2. The following shall be submitted:
  - a. Complete bill of materials.
  - b. Drawings indicating the locations of all pull boxes with station numbers.
  - c. Catalog data on all testing devices proposed for use plus certifications of accuracy, calibration, and traceability to standards of the National Institute for Standards and Testing.
  - d. Cable pulling calculations for all conduit runs. Indicate on the submittal any additional pull boxes that are required, including station number and a written description, of the location.
  - e. A cable pulling and splicing work plan shall be submitted a minimum of 45 days prior to the planned initiation of cable pulling. The pulling plan and pull tension calculations may be prepared by using a software program such as Pull-Planner 2000 by American Polywater Corporation. The cable pulling and splicing work plan must be approved a minimum of 15 days prior to pulling cable. Work plan shall include the following:
    - 1) Pull tension calculations
    - 2) Calculated amount of lubrication required
    - 3) Detailed description of pull operation methods for all conduit runs

#### Quality Assurance

3. All work described in this section shall meet or exceed the applicable provisions of the following documents:
  - a. ANSI C8.471983, American National Standard for Polyolefin Insulated Thermoplastic Jacketed Communication Cables.
  - b. EIA-455 (addendum 1 through 5) Standard Test Procedures for Fiber Optics, Cables, Transducers, Connecting and Terminating Devices.
  - c. EIA-455-27A, Method of Measuring (Uncoated) Diameter of Optical Waveguide Fibers.
  - d. EIA-455-28A, Method For Measuring Tensile Failure Point of Optical Waveguide Fibers.
  - e. EIA-455-34, Interconnection Device Insertion Loss Test.
  - f. EIA-455-89, Fiber Optic Cable Jacket Elongation and Tensile Strength.

#### Warranty

4. The Contractor shall provide an unconditional warranty on all installed cable for a minimum period of two (2) years.

### PRODUCTS

#### Materials

5. Fiber Optic Cable - 24 strand
  - a. Cable type: Outdoor Plant Stranded Loose-Tube, Gel-Filled Fiber Optic Cable, Corning Altos 024RW4-14101A20 or Lucent Lightpack 7D1X-024-BXD.
  - b. Number of fibers: 24 fibers.
  - c. Buffer Tubes: All optical fibers shall be placed inside a loose buffer tube. The optical cable shall contain three buffer tubes, numbered 1, 2, and 3. The tubes shall be color coded according to the table below:

Buffer Tube Number	Buffer Tube Color
1	Blue
2	Orange
3	Green

- d. Each buffer tube shall contain 8 singlemode fibers. Each fiber shall be numbered and distinguishable by means of the color coding established in the main body of the specification.
  - e. The colors of the individual fibers shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.
  - f. The fibers shall not adhere to the inside walls of the loose buffer tube. Buffer tubes shall be kink resistant within the specified minimum bend radius.
  - g. Filler may be included in the cable core composition to lend symmetry to the cable cross-section where needed.
  - h. A central anti-buckling member shall be included into the cable to prevent buckling of the cable. The anti-buckling member shall be composed of a glass reinforced plastic rod.
  - i. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.
  - j. Buffer tubes shall be stranded around a central member using the reverse oscillation, or "S-Z", stranding process.
  - k. The cable core shall contain a water-blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.
  - l. Binders shall be applied with sufficient tension to secure the buffer tubes to the member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.
  - m. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.
  - n. The all-dielectric cable shall be sheathed with medium density polyethylene (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking material. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metallic elements and shall be of a consistent thickness.
  - o. The cable shall contain at least one ripcord under the sheath for easy sheath removal.
6. Fiber Optic Cable - 36 Strand
- a. Cable type: Outdoor Plant Stranded Loose-Tube, Gel-Filled Fiber Optic Cable, Corning Altos 036RW4-14101A20 or Lucent Lightpack 7D1X-036-BXD.
  - b. Number of fibers: 36 fibers.
  - c. Buffer Tubes: All optical fibers shall be placed inside a loose buffer tube. The optical cable shall contain three buffer tubes, numbered 1, 2, and 3. The tubes shall be color coded according to the table below:

Buffer Tube Number	Buffer Tube Color
1	Blue
2	Orange
3	Green

- d. Each buffer tube shall contain 12 single mode fibers. Each fiber shall be numbered and distinguishable by means of the color coding established in the main body of the specification.

- e. The colors of the individual fibers shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the gel filling material. Colors shall not cause fibers to stick together.
- f. The fibers shall not adhere to the inside walls of the loose buffer tube. Buffer tubes shall be kink resistant within the specified minimum bend radius.
- g. Filler may be included in the cable core composition to lend symmetry to the cable cross-section where needed.
- h. A central anti-buckling member shall be included into the cable to prevent buckling of the cable. The anti-buckling member shall be composed of a glass reinforced plastic rod.
- i. Each buffer tube shall be filled with a non-hygroscopic, non-nutritive to fungus, electrically non-conductive, homogenous gel. The gel shall be free from dirt and foreign matter. The gel shall be readily removable with conventional nontoxic solvents.
- j. Buffer tubes shall be stranded around a central member using the reverse oscillation, or "S-Z", stranding process.
- k. The cable core shall contain a water-blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.
- l. Binders shall be applied with sufficient tension to secure the buffer tubes to the member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.
- m. Tensile strength shall be provided by a combination of high tensile strength dielectric yarns. The high tensile strength dielectric yarns shall be helically stranded evenly around the cable core.
- n. The all-dielectric cable shall be sheathed with medium density polyethylene (MDPE). The minimum nominal jacket thickness shall be 1.4 mm. Jacketing material shall be applied directly over the tensile strength members and water blocking material. The jacket or sheath shall be free of holes, splits, and blisters. The cable jacket shall contain no metallic elements and shall be of a consistent thickness.
- o. The cable shall contain at least one ripcord under the sheath for easy sheath removal.
- 7. Fan-Out Termination for Loose Tube Cables
  - a. Individual fibers within the loose tube cable require handling protection inside the termination cabinets. Fan-out kits shall be installed in the patch panel enclosures to transition the loose tube fibers to ruggedized tight-buffered fiber pigtail cables. Fan-out tubes or furcation kits shall not be used. Optical fusion splices shall connect the loose tube fibers to the tight-buffered pigtail cables. The optical splice loss shall comply with the specifications for optical splices. Splice protection sleeves shall be employed on all splices to protect the splices. A wall-mountable splice center shall house the splices and serve to fully protect excess lengths of loose tube fibers from exposure.
  - b. The tight-buffered pigtails shall be terminated with ST connectors as specified.
- 8. Fan-out Pigtail Cable Specifications
  - a. Singlemode fiber (Corning SMF-28) shall be used in the pigtails. Optical characteristics shall comply with the optical fiber performance specifications.

Buffer material	Thermoplastic
Buffer O.D.	900 um
Strength Member	Kevlar
Jacket Material	PVC
Jacket O.D.	3.0 mm
Temperature Range	-20 to +70 C

- 9. Fiber Optic Termination Patch Panels:
  - a. Where shown on the plans or in the Appendix, the fiber optic cable shall terminate inside a communications cabinet on a termination patch panel. All fiber sub-cables within the cable shall be terminated with "ST<sup>TM</sup> compatible" connectors. The patch panel shall have a 24-fiber capacity, and shall facilitate fiber-optic cable cross-connection between outside plant





- cables and opto-electronic interface equipment cabling. The patch panel shall contain "ST™" type bayonet couplings. All unused couplings shall have protective dust covers. Factory-terminated, tight-buffered, aramid-reinforced fiber optic jumper assemblies or interconnect cables, standard 3.0-mm O.D., shall connect the optical cable terminations to the patch panel couplings.
- b. The termination panel shall be equipped with a suitable means for routing and securing of cables and shall provide a suitable means of protection for the mounted fiber connectors, to prevent damage to fibers and connectors during all regular operation and maintenance functions. Bend diameters on cable fibers and jumpers must be greater than four (4) inches at all times to ensure optical and mechanical integrity of the optical fibers.
10. Optical Connectors
- a. All connectors shall be field-installable and perfectly matched to the cable used. The connectors shall provide tight fitting termination, to the cladding and buffer coating. Epoxy-based or "hot melt" adhesives shall be used to bond the fiber and buffer to the connector ferrule and body prior to polishing the end face. No dry-termination or "quick crimp" connectors are allowed.
  - b. After termination with connectors, the fiber ends must be visually inspected at a magnification of not less than 100 power to check for cracks or pits in the end face of the fiber. If any irregularities found cannot be removed by further polishing, the entire process must be redone by cutting off and disposing the connector body.
  - c. Connectors shall have a maximum allowable connection loss of 0.3 dB per mated pair, as measured per EIA-455-34. No index-matching gel is to be used, dry interfaces only. Singlemode connectors shall be capable of field installation on 9/125 micron fibers with 900 micron buffers (OD).
  - d. Each connector shall be of the industry standard ST type compatible, designed for singlemode tolerances, and shall meet or exceed the applicable provisions of EIA-455-5, 455-2A, and 455-34, and shall be capable of 100 repeated matings with a maximum loss increase of 0.1 dB. Connectors shall incorporate a key-way design and shall have a zirconia ceramic ferrule. Connector bodies and couplings shall be made of corrosion-resistant and oxidation-resistant materials, such as nickel plated zinc, designed to operate in humid environments without degradation of surface finishes.
11. Splice Closures:
- a. Splice closures shall be of the re-enterable type, with an external moisture-proof shell, inner closure and encapsulant.
  - b. Closure shall have removable interior splice trays.
  - c. Closures shall be Corning Cable Systems (Sicor) type SCN or equal.

## EXECUTION

### Fiber Optic Cable Installation

12. General:
- a. The Contractor shall determine a suitable cable installation method to ensure that all cable installation requirements shall be met in all conduit sections. All work shall be carried out in accordance and consistent with the highest standards of quality and craftsmanship in the communication industry with regard to the electrical and mechanical integrity of the connections; the finished appearance of the installation; as well as the accuracy and completeness of the documentation.
  - b. The Contractor shall make a physical survey of the project site for the purpose of establishing the exact cable routing and cutting lengths prior to the commencement of any work or committing any materials.
  - c. The cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the the Owner notified.

- d. Precautions shall be taken during installation to prevent the cable from being kinked or crushed. Crushed or kinked cable shall be replaced with new cable. As the cable is pulled into the conduit system, it shall be sufficiently lubricated with a lubricant that shall be the water-based type and approved by the cable manufacturer. Lubricant shall be applied at a rate to provide a continuous 10-mil coating, as recommended by the manufacturer. Lubricant shall be Polywater F® manufactured by American Polywater, or approved equivalent.
  - e. The mechanical stress placed upon the cable during installation shall not be such that the cable is twisted and stretched or exceeds manufacturer's specifications.
  - f. The pulling of the cable shall be hand assisted at each handhole or pullbox. When pulling through intermediate pullboxes, the cable shall be placed on the ground near the pullbox and care taken to prevent damage by vehicles or other objects. The cable shall not be crushed, kinked or forced around a sharp corner. A minimum of 3 foot slack shall be left in each pullbox and enough left at each end of the cable to allow proper cable termination.
13. Fiber optic cables shall be installed in continuous lengths without intermediate splices throughout the project. Cable installation personnel shall be familiar with the manufacturer's recommended procedures including, but not limited to the following:
- a. Proper attachment to the cable strength elements for pulling during installation. Depending on cable design, this will involve direct attachment to internal strength members or attaching an external "Kellums" or split mesh grip using a 600 lb breakaway swivel.
  - b. Cable tensile limitations and tension monitoring procedures.
  - c. Cable bending radius limitations.
  - d. Cable twisting limitations.
14. The Contractor shall comply with the cable manufacturer's recommended installation procedures at all times. Cable installation procedures shall conform to Belcore guidelines.
15. To accommodate long continuous installation lengths, bi-directional "center pull" techniques for pulling of the fiber optic cable is acceptable and shall be implemented as follows:
- a. From the midpoint, pull the fiber optic cable into the conduit from the shipping reel in accordance with the manufacturer's specifications.
  - b. When this portion of the pull is complete, the remainder of the cable must be removed from the reel to make the inside end available for pulling in the opposite direction.
  - c. This is accomplished by hand pulling the cable from the reel and laying into large "figure eight" loops on the ground.
  - d. The purpose of the figure eight pattern is to avoid cable tangling and kinking.
  - e. The loops shall be laid carefully one upon the other (to prevent subsequent tangling) and shall be in a protected area.
  - f. The inside reel end of the cable is then available for installation.
  - g. In some cases, it may be necessary to set up a winch at an intermediate cable vault.
  - h. The required length of cable shall be pulled to that point, and brought out of the cable vault and coiled into a figure eight.
  - i. The figure eight is then turned over to gain access to the free cable end. This can then be reinserted into the duct system for installation into the next section.
16. At pullboxes, the Contractor shall provide 30 feet of cable slack. The fiber optic cable shall be coiled and secured with cable ties in the pullbox. The Contractor shall ensure that the minimum bending radius of the fiber optic cable is not compromised when preparing this stored cable slack.
17. The pulling eye/sheath termination hardware on the fiber optic cables shall not be pulled over any sheave blocks.
18. When power equipment is used to install fiber optic cabling, the pulling speed shall not exceed 30 meters per minute. The pulling tension, bending radius and twist limitation for fiber optic cable shall not be exceeded under any circumstances.
19. Large diameter wheels, pulling sheaves, and cable guides shall be used to maintain the appropriate bending radius. Tension monitoring shall be accomplished using commercial dynamometers or loadcell instruments.
- a. All pulls shall be documented by a graph which is annotated with the following information:
    - 1) Reel number
    - 2) Station from and station to



- 3) Date and tune
- 4) Explanations of abnormalities in readings or interruptions
- 5) Sign-off by Contractor and the Owner
- b. Under no conditions shall the FOC be left exposed or unattended.
20. Repairs: Repair of cable jacket will not be permitted. Jacket damage will require removal and re-installation of a new cable run at the Contractor's expense.
21. Splicing:
  - a. Splicing of fiber optic cable shall not be permitted except in emergency conditions or as specified on the plans or in the special conditions for a specified project. Fiber optic cable runs and required looping of the cable shall be provided in one continuous length. When splicing is authorized by the the Owner, splicing shall be by trained, authorized persons only. Any allowed splicing of fiber optic cable shall be by fusion splice only, no mechanical splices are permitted.
  - b. All fusion splicing equipment shall be in good working order, properly calibrated, and meeting all industry standards and safety regulations. Cable preparation, closure installation and splicing shall be accomplished in accordance with accepted and approved industry standards.
  - c. Splices shall be made in pullboxes and shall use re-enterable splice closures.
  - d. The average splice loss shall be 0.1 dB or less per splice. The average splice loss is defined as the summation of the loss as measured in both directions using an optical time domain reflectometer (OTDR) through the fusion splice, divided by two. No individual splice loss measured in a single direction shall exceed 0.15 dB.
  - e. Upon completion of the splicing operation, all waste material shall be deposited in suitable containers, removed from the job site, and disposed of in an environmentally acceptable manner.
22. After the cables are installed and spliced, they shall be racked and all conduits sealed. A minimum of 30 feet of FOC shall be stored at each end of one splice. Racking shall conform to the following:
  - a. Cables shall be loosely secured in racked position with Ty-Raps or equal.
  - b. Imprinted plastic coated cloth identification/warning tags shall be securely attached to the cables in at least two locations in each handhole. Tags shall be by Brady or Thomas & Betts.
  - c. All coiled cable shall be suitably protected to prevent damage to the cable and fibers. Racking shall include securing cables to brackets and racking hardware that extend from the sidewalls of the handhole.
  - d. When all cables at each handhole are securely racked, unused conduits and void areas around conduit containing cables shall be sealed.

#### Cable Protection During Installation

23. All fiber optic cable shall be pulled in conduit except as specified on the plans. Care shall be exercised during cable pulls through conduit bends and looping in pull boxes.
24. To reduce the possibility of damage to the outer jacket of the fiber optic cable, protective measures shall be used when the cable is installed. The requirements herein shall be followed, but does not limit the installation to only those identified. The purpose of the installation specifications is to ensure protection, of the fiber optic cable when it is installed. Other protective measures not specified herein may be taken during installation if it will ensure protection of the cable.
25. A cable feeder guide shall be used between the cable reel and the face of the duct and conduit to protect the cable and guide it off the reel and into the duct. The cable shall be carefully inspected for jacket defects as it is removed from the reel. If defects are noticed, the pulling operation shall be terminated immediately and the the Owner notified.
26. Precautions shall be taken during installation to prevent the cable from being kinked, crushed or twisted. A pulling eye shall be attached to the cable end and be used to pull the cable through the duct and conduit system. As the cable is pulled off the reel and into the cable feeder guide, it shall

- be sufficiently lubricated with a lubricant that shall be of the water based type and approved by the cable manufacturer.
27. Dynamometers or break away pulling swings shall be used to ensure the pulling line tension does not exceed the installation tension values specified by the cable manufacturer. The mechanical stress placed upon the cable during installation shall not be such that the cable is twisted and stretched. Maximum allowable cable strain during installation shall be less than 0.75%.
  28. The pulling of the cable shall be hand assisted at each handhole or pullbox. The cable shall not be crushed, kinked or forced around a sharp corner. Sufficient slack shall be left at each end of the cable to allow proper cable termination.
  29. The cable shall be looped in all pull boxes as noted on the plans to provide approximately thirty (30) feet of extra cable in the pull box. At termination points, such as at cabinets or computers, a thirty (30) foot loop shall also be provided wherever space permits.
  30. Cable Marking: At each pullbox and at each cabinet, the cable shall be visibly marked with yellow warning tape as follows:

**"CAUTION - FIBER OPTIC CABLE"**

Fiber Optic Cable Testing

31. General: The Contractor shall perform pre-installation and post-installation FOC tests. The the Owner shall be notified a minimum of 10 days in advance so that these tests are witnessed. All test equipment shall be traceable to NIST standards.
32. Test equipment: The Contractor, shall use the following to perform pre-installation and post-installation FOC tests:
  - a. Optical time domain reflectometer (OTDR). The OTDR shall be laser precision, ALT Inc. MODEL 5200 LRFL, or equal.
33. Pre-installation tests
  - a. The purpose of these tests is to perform acceptance tests on the cable prior to installation to verify that the cable conforms to the manufacturer's specifications, and is free of defects, breaks and damages by transportation and manufacturing processes.
  - b. Prior to removal of each cable from the delivery reel, all optical fibers within the cables shall be tested by the Contractor using an OTDR. The OTDR tests shall consist of end-to-end length and fiber attenuation (dB/km) measurements to ensure proper performance of the fiber optic cable. The tests shall be performed from both ends of each fiber to ensure complete fiber continuity within the cable structure.
  - c. Pre-installation, "on-reel" test results shall be compared with the manufacturer's test report delivered with the cable. Gross dissimilarities shall be noted and remedied between the Contractor and manufacturer. In all cases, all fibers must meet the optical attenuation specifications prior to cable installation.
  - d. The Contractor shall perform tests on all reels of cable. The the Owner shall be notified a minimum of 15 days prior to any test.
  - e. The Contractor shall document each test and submit the report to the the Owner for review. Documentation shall consist of both hard copy and 3-1/2 inch electronic disk complete with all application software.
  - f. Cable shall not be installed until the the Owner has reviewed the test report.
  - g. Maximum allowable attenuation is 0.5 dB/km at 1310 and 1550 nm.
34. Post-installation tests: After FOC has been installed the following tests shall be performed:
  - a. A recording OTDR shall be used to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall be equipped with a 1310 nm and 1550 nm light source for the single mode fiber (SMF). The OTDR shall have an X-Y plotter to provide a hard copy record of each trace of each fiber: The OTDR shall be equipped with sufficient internal masking to allow the entire cable section to be tested. This may be achieved by using an optical fiber pigtail of 30 feet or more to display the required cable section.
  - b. The OTDR shall be calibrated for the correct index of refraction to provide proper length measurement for the known length of reference fiber.



- c. A transmission test shall be performed with the use of a 1310 and 1550 nm stabilized light sources and 1310 nm/1550 nm power meters for SMF. This test shall be conducted in both directions on each fiber of each cable.
  - d. Hard and electronic copy of test documentation shall be submitted to the the Owner. The documentation shall include the trace plot, index, dB/km loss, cable length, date and time of test, wavelength, pulse width, the test site, cable ID, fiber number and type, and operator's initials. The Contractor shall compare the pre-installation test results to the post-installation results. If a deviation of greater than one dB occurs, the the Owner shall be notified in writing by the Contractor, and the cable shall be removed and replaced at no additional cost to the Owner.
  - e. Upon completion of the previous tests all FOC coils shall be secured with ends capped to prevent intrusion of dirt and water.
35. Required OTDR Trace Information:
- a. All traces shall display the entire length of cable under test, highlighting any localized loss discontinuities (installation-induced losses and/or connector losses). The trace shall display fiber length (in kilofeet), fiber loss (dB), and average fiber attenuation (in dB/km) as measured between two markers placed as near to the opposite ends of the fiber under test as is possible while still allowing an accurate reading. Care shall be taken to ensure that the markers are placed in the linear region of the trace: away from the front-end response and far-end Fresnel reflection spike. Time averaging shall be used to improve the display signal to noise ratio. The pulse width of the OTDR shall be set to a sufficient width to provide adequate injected power to measure the entire length the fiber under test.
  - b. If connectors exist in the cable under test, then two traces shall be recorded. One trace shall record the fiber loss (dB) and average attenuation (dB/km) of the entire cable segment under test, including connectors. The second trace shall display a magnified view of the connector regions, revealing the connector losses (dB). All connector losses shall be measured using the 5-point splice loss measurement technique.
  - c. The OTDR trace shall also include the following information:
    - 1) The date and time of the test
    - 2) The cable ID number
    - 3) The cable segment ID number
    - 4) The fiber color or sub-cable number
    - 5) Launch point connector number
    - 6) The optical wavelength used for the test
    - 7) The refractive index setting of the OTDR
    - 8) The pulse width setting of the OTDR
    - 9) The averaging interval of the test

END OF SECTION 27 11 19 00

Task	Specification	Specification Description
27 11 19 00	26 05 53 00a	Intercommunications and Program Systems
27 11 23 00	26 05 53 00a	Intercommunications and Program Systems
27 13 13 13	26 05 13 16	Conductors And Cables
27 13 13 13	26 05 13 16a	Undercarpet Cables
27 13 13 13	26 05 13 16b	Medium-Voltage Cables
27 13 13 13	26 05 53 00a	Intercommunications and Program Systems
27 13 23 13	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 15 13 00	26 05 13 16	Conductors And Cables
27 15 13 00	26 05 13 16a	Undercarpet Cables
27 15 13 00	26 05 19 16c	Control-Voltage Electrical Power Cables
27 15 13 00	26 05 13 16b	Medium-Voltage Cables
27 15 33 00	26 05 13 16	Conductors And Cables
27 15 33 00	26 05 13 16a	Undercarpet Cables
27 15 33 00	26 05 19 16c	Control-Voltage Electrical Power Cables
27 15 33 00	26 05 13 16b	Medium-Voltage Cables
27 15 43 00	26 05 53 00a	Intercommunications and Program Systems
27 15 53 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 16 16 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 16 19 00	26 05 13 16	Conductors And Cables
27 16 19 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 21 16 00	27 11 19 00	Loose-Tube Gel-Filled Fiber Optic Cables
27 21 16 00	26 05 53 00a	Intercommunications and Program Systems
27 31 13 00	26 05 53 00a	Intercommunications and Program Systems
27 32 13 00	26 05 33 16a	Wiring Devices
27 32 13 00	26 05 53 00a	Intercommunications and Program Systems
27 32 26 00	26 05 53 00a	Intercommunications and Program Systems

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## SECTION 27 51 43 00 - EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for educational intercommunications and program systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes: Manually switched intercommunications, Microprocessor-switched intercommunications, Microprocessor-switched telephone/intercommunications and program systems with the following components:
  - a. Master stations.
  - b. Call control console.
  - c. Speaker-microphone stations.
  - d. Call-switch unit.
  - e. All-call amplifier.
  - f. Intercommunication amplifier.
  - g. Paging amplifier.
  - h. Loudspeakers/speaker microphones.
  - i. Conductors and cables.
  - j. Raceways.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For educational intercommunications and program systems. Include plans, elevations, sections, details, and attachments to other work.
  - a. Wiring Diagrams: For power, signal, and control wiring.
    - 1) Identify terminals to facilitate installation, operation, and maintenance.
    - 2) Single-line diagram showing interconnection of components.
    - 3) Cabling diagram showing cable routing.
3. Field quality-control reports.
4. Operation and maintenance data.

#### D. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for location and application.
3. Comply with NFPA 70.

### 1.2 PRODUCTS

#### A. Functional Description Of Manually Switched Systems

1. Master Station:
  - a. Communicating selectively with other master and speaker-microphone stations by actuating selector switches.
  - b. Communicating simultaneously with all other stations by actuating a single all-call switch.
  - c. Communicating with individual stations in privacy.
  - d. Including other master-station connections in a multiple-station conference call.





- e. Accessing separate paging speakers or groups of paging speakers by actuating selector switches.
- f. Overriding any conversation by a designated master station.
- 2. Speaker-Microphone Station:
  - a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
  - b. Communicating hands free.
  - c. Calling master station by actuating call switch.
  - d. Returning a busy signal to indicate that station is already in use.
  - e. Being free of noise and distortion during operation and when in standby mode.
- 3. Speakers: Free of noise and distortion during operation and when in standby mode.

#### B. Functional Description Of Microprocessor-Switched Systems

- 1. Master Station:
  - a. Communicating selectively with other master and speaker-microphone stations by dialing station's number on a 12-digit keypad.
  - b. Communicating with individual stations in privacy.
  - c. Communicating on a minimum of three voice channels with up to two simultaneous conversations between master stations and one conversation between a master station and a speaker-microphone station.
  - d. Increasing the number of conversation channels by adding a module in central-control cabinet.
  - e. Including up to three other station connections in a conference call.
  - f. Accessing separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
  - g. Overriding any conversation by a designated master station.
  - h. Displaying selected station.
  - i. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
  - j. Automatically controlling gain to ensure constant intercom speech level.
  - k. Controlling the simultaneous distribution of program material to various combinations of speaker-microphone stations or groups over two program channels by using keypad to control sources and distribute programs.
  - l. Operating and correcting secondary clocks and controlling class-change signals to speakers and bells by using keypad.
  - m. User-programmable features include the following:
    - 1) Station calling by room number.
    - 2) Room station call-in priority levels.
    - 3) Clock signal schedule functions.
    - 4) Schedule characteristics of audible signals.
    - 5) Call-in tone characteristic.
    - 6) Precedence among master stations as destinations for incoming calls from room stations.
    - 7) Grouping of rooms and speakers into zones for paging and program distribution purposes.
- 2. Speaker-Microphone Station:
  - a. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
  - b. Communicating hands free.
  - c. Calling master station by actuating call switch.
  - d. Returning a busy signal to indicate that station is already in use.
- 3. Speakers: Free of noise and distortion during operation and when in standby mode.

C. Functional Description Of Telephone/Intercommunication Systems

1. Integrated central system with the following:
  - a. Direct-dial, full duplex private telephone communications between all locations equipped with telephones. Call initiation among master stations and between master and remote stations by dialing station's number on a 12-digit keypad.
  - b. 16 channels for unrestricted simultaneous communications.
  - c. Initial system operation with **<Insert number>** master and remote stations, expandable to 360 stations.
  - d. Direct-dial, two-way amplified voice intercommunication between master telephones and remote stations without use of press-to-talk or talk-listen switches.
  - e. Automatic queuing for intercommunication channels, with automatic call waiting.
  - f. Call transfer among master stations.
  - g. Display of selected station and answering calling station by pressing a single "response button."
  - h. Simultaneous communication with other stations on system by dialing a designated number on a 12-digit keypad.
  - i. Automatic gain control to ensure constant intercom speech level.
  - j. Simultaneous distribution of emergency announcements to all locations equipped with speakers by dialing a predetermined code number.
  - k. User-selectable facility for providing selected telephones with dial tone.
  - l. User-selectable facility for permitting linkage of selected stations to media retrieval center and for permitting on- and off-premise computer linkage.
  - m. Assignment of speaker locations within any one or more of eight zones for zone paging or time signal reception.
  - n. Digital readout displays on which up to three incoming calls are displayed with additional calls stored for subsequent display.
  - o. Off-site diagnostics through a serial data port on central-control station.
  - p. Control of simultaneous distribution of program material to various combinations of remote stations or groups by using keypad to control sources and distribute programs.
  - q. Operation and correction of secondary clocks and control of class-change signals to speakers and bells by using keypad.
  - r. User-programmable features include the following:
    - 1) Station calling by room number.
    - 2) Room station call-in priority levels.
    - 3) Clock signal schedule functions.
    - 4) Schedule characteristics of audible signals.
    - 5) Call-in tone characteristic.
    - 6) Precedence among master stations as destinations for incoming calls from room stations.
    - 7) Grouping rooms and speakers into zones for paging and program distribution purposes.
  - s. Telephone interconnect features include the following:
    - 1) Direct connection to central office trunk lines with initial system wiring for **<Insert number>** trunk lines.
    - 2) Routing of outside trunk lines for "attendant answer incoming" and "direct inward line" functions.
    - 3) Station programming for access to outside trunk lines to be any of the following:
      - a) Totally unrestricted access.
      - b) Restricted access.
      - c) No access.
    - 4) System programming to allow or disallow local prefixes, and to authorize access for as many as three area codes.
    - 5) Discriminating ringing for identifying internal and outside calls.
    - 6) Circular hunting for outside trunks to prevent excess usage of any one trunk.
    - 7) Direct connection of a single trunk to designated telephone with transfer to attendant if unanswered.



- 8) Call parking allowing paged party to remotely pick up outside call from any master station.
  - 9) Night-answer mode to allow one or all of the following:
    - a) Incoming call transferred to predetermined extension.
    - b) Tone transmitted to speakers to notify key personnel to answer telephone.
    - c) Dial tone to remote stations to allow answering call from all locations.
  - 10) Call control console to do as follows:
    - a) Identify, answer, and route incoming outside calls, with reminder and recall features.
    - b) Directly access outside trunk lines.
    - c) Hold, park, and transfer calls.
    - d) Screen outside calls.
  2. Remote Stations:
    - a. Speaker-Microphone Station:
      - 1) Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
      - 2) Communicating hands free.
      - 3) Calling master station by actuating call switch.
      - 4) Returning a busy signal to indicate that station is already in use.
  3. Speakers: Free of noise and distortion during operation and when in standby mode.
- D. General Requirements For Equipment And Materials
1. Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.
  2. Expansion Capability: Increase number of stations in the future by 25 percent above those indicated without adding any internal or external components or main trunk cable conductors.
  3. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz. Comply with UL 813.
  4. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.
- E. Master Station For Manually Switched Systems
1. Station-Selector and Talk-Listen Switches: Heavy-duty type with gold-plated contacts rated for five million operations.
  2. Volume Control: Regulates incoming-call volume.
  3. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.
  4. Tone Annunciation: Momentary audible tone signal announces incoming calls.
  5. Speaker Microphone: Transmits and receives calls.
    - a. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.
  6. Handset with Hook Switch: Telephone type with **18-inch- (450-mm-)** long, permanently coiled cord. Arrange to disconnect speaker when handset is lifted.
  7. Central-Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and auxiliary equipment.
- F. Master Station For Microprocessor-Switched Systems
1. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.
  2. Volume Control: Regulates incoming-call volume.
  3. Tone Annunciation: Momentary audible tone signal announces incoming calls.
  4. Lamp Annunciation: Identifies calling stations and stations in use. Lamp remains on until call is answered.

5. Speaker Microphone: Transmits intercom voice signals when used via a voice-operated switch.
    - a. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.
  6. Link Button: To transfer calls.
  7. Reset Control: Cancels call and resets system for next call.
  8. Digital Display: 16-digit alphanumeric LCD readout to register up to four three-digit station numbers.
  9. Central-Equipment Cabinet: Comply with TIA/EIA-310-D. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.
- G. Call Control Console
1. Microprocessor-based instrument to process outside and internal calls with a 12-digit keypad selector.
  2. 20-character alphanumeric display for the following:
    - a. Simultaneous display of up to three calling stations plus last station dialed.
    - b. Display of calls in order received with emergency calls taking precedence on the display.
    - c. Review of calls stored in groups of four.
    - d. Display of prompt messages to assist in system operation.
  3. Programmable Keys: Minimum of 20 with LED indicators for ringing/busy status; programmable for trunk and operator functions.
  4. Transfer Button: Calls to busy extensions and unanswered calls automatically returned to call control console.
  5. Hold Button: With reminder feature every 30 seconds for parked calls or calls placed on hold.
  6. Release Button: For use with parked calls or calls placed on hold.
  7. Page Button: For engaging system paging functions.
  8. Programmable for night answer, remote answer, and remote pickup features.
  9. Programmable for distribution of emergency announcements, all-page announcements, zone-page announcements, and emergency/evacuation alert.
  10. Central-Control Cabinet Equipment: Central switching equipment, central office adapter module, line link modules, power supplies, chassis adapters, and other switching and control devices required for trunk and internal conversation channels and control functions.
- H. Speaker-Microphone Stations
1. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.
  2. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.
  3. Back Box: Two-gang galvanized steel with 2-1/2-inch (64-mm) minimum depth.
  4. Speaker: Minimum axial sensitivity shall be 91 dB at one meter, with 1-W input. Voice coil shall be not less than 3 inches (76 mm), 2.3 oz. (65 g) minimum; permanent magnet.
  5. Tone Annunciation: Recurring momentary tone indicates incoming calls.
  6. Call Switch: Mount on faceplate. Permits calls to master station.
  7. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.
- I. Call-Switch Unit
1. Enclosure: Single-gang box with stainless-steel faceplate.
  2. Call Switch: Momentary contact signals system that a call has been placed.
  3. Privacy Switch: Prevents transmission of sound signals from station to system.
  4. Volume Control: Operated by screwdriver blade through a hole in faceplate to adjust output level of associated speaker.
- J. All-Call Amplifier
1. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.



2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.
  3. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
  4. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
  5. Output Regulation: Maintains output level within 2 dB from full to no load.
  6. Input Sensitivity: Compatible with master stations and central equipment so amplifier delivers full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on master stations, speaker microphones, or handset transmitters.
  7. Amplifier Protection: Prevents damage from shorted or open output.
- K. Intercommunication Amplifier
1. Minimum Output Power: 15 W; adequate for all functions.
  2. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.
  3. Minimum Signal-to-Noise Ratio: 50 dB, at rated output.
  4. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.
  5. Output Regulation: Maintains output level within 2 dB from full to no load.
  6. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on microphones in master stations, speaker microphones, or handset transmitters.
  7. Amplifier Protection: Prevents damage from shorted or open output.
- L. Paging Amplifier
1. Input Voltage: 120-V ac, 60 Hz.
  2. Frequency Response: Within plus or minus 3 dB from 60 to 10,000 Hz.
  3. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.
  4. Total Harmonic Distortion: Less than 3 percent at rated output power from 70 to 12,000 Hz.
  5. Output Regulation: Less than 2 dB from full to no load.
  6. Controls: On-off, input levels, and low-cut filter.
  7. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphones or handset transmitters.
  8. Amplifier Protection: Prevents damage from shorted or open output.
- M. Cone-Type Loudspeakers/Speaker Microphones
1. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.
  2. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.
  3. Minimum Dispersion Angle: 100 degrees.
  4. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.
  5. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least **0.0478-inch (1.2-mm)** steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.
  6. Baffle: For flush speakers, minimum thickness of **0.032-inch (0.8-mm)** aluminum brushed to a satin sheen and lacquered **OR** with textured white finish, **as directed**.
  7. Vandal-Proof, High-Strength Baffle: For flush **OR** surface, **as directed**, -mounted speakers, self-aging cast aluminum with tensile strength of **44,000 psi (303 MN/sq. m)**, **0.025-inch (0.65-mm)** minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.
  8. Size: **8 inches (200 mm)** with **1-inch (25-mm)** voice coil and minimum **5-oz. (140-g)** ceramic magnet.
- N. Horn-Type Loudspeakers/Speaker Microphones
1. Speakers shall be all-metal, weatherproof construction; complete with universal mounting brackets.

2. Frequency Response: Within plus or minus 3 dB from 275 to 14,000 Hz.
3. Minimum Power Rating of Driver: 15 W, continuous.
4. Minimum Dispersion Angle: 110 degrees.
5. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

O. Conductors And Cables

1. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but no smaller than No. 22 AWG.
2. Insulation: Thermoplastic, not less than **1/32 inch (0.8 mm)** thick.
3. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG, tinned, soft-copper strands formed into a braid or equivalent foil.
  - a. Minimum Shielding Coverage on Conductors: 60 percent.
4. Plenum Cable: Listed and labeled for plenum installation.

P. Raceways

1. Educational Intercommunication and Program System Raceways and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems".
2. Educational Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
3. Educational Intercommunication and Program System Raceways and Boxes: EMT **OR** ENT **OR** RNC **OR** Optical-fiber/communication raceways and fittings **OR** Metal wireways **OR** Nonmetal wireways **OR** Surface metal raceways **OR** Surface nonmetal raceways, **as directed**.
4. Outlet boxes shall be not less than **2 inches (50 mm)** wide, **3 inches (75 mm)** high, and **2-1/2 inches (64 mm)** deep.
5. Flexible metal conduit is prohibited.

### 1.3 EXECUTION

A. Wiring Methods

1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used, **as directed**. Conceal raceway and cables except in unfinished spaces.
  - a. Install plenum cable in environmental air spaces, including plenum ceilings.
  - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".
2. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
3. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

B. Installation Of Raceways

1. Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems" for installation of conduits and wireways.
2. Install manufactured conduit sweeps and long-radius elbows whenever possible.

C. Installation Of Cables

1. Comply with NECA 1.
2. General Requirements:
  - a. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.





- b. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
    - c. Secure and support cables at intervals not exceeding **30 inches (760 mm)** and not more than **6 inches (150 mm)** from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
    - d. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.
    - e. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
    - f. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.
  - 3. Open-Cable Installation:
    - a. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
    - b. Suspend speaker cable not in a wireway or pathway a minimum of **8 inches (200 mm)** above ceiling by cable supports not more than **60 inches (1524 mm)** apart.
    - c. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.
  - 4. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least **12 inches (300 mm)** apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.
- D. Installation
- 1. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.
  - 2. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.
  - 3. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.
  - 4. Connect wiring according to Division 26 Section "Grounding And Bonding For Electrical Systems".
- E. Grounding
- 1. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
  - 2. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.
  - 3. Install grounding electrodes as specified in Division 26 Section "Grounding And Bonding For Electrical Systems".
- F. System Programming
- 1. Programming: Fully brief the Owner on available programming options. Record the Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.
- G. Field Quality Control
- 1. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

2. Tests and Inspections:
  - a. Schedule tests with at least seven days' advance notice of test performance.
  - b. After installing educational intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.
  - c. Operational Test: Test originating station-to-station **OR** originating station-to-station, all-call, and page, **as directed**, messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.
  - d. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging, **as directed**, by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
  - e. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:
    - 1) Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at paging, **as directed**, speakers.
    - 2) Repeat test for three speaker microphones, one master station microphone, and for each separately controlled zone of paging loudspeakers.
    - 3) Minimum acceptable ratio is 45 dB.
  - f. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each intercom **OR** intercom, paging, and all-call amplifier, **as directed**. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.
  - g. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.
  - h. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.
  - i. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".
3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.
4. Educational intercommunications and program systems will be considered defective if they do not pass tests and inspections.
5. Prepare test and inspection reports.

END OF SECTION 27 51 43 00



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Task	Specification	Specification Description
27 51 43 00	26 33 43 00b	Public Address and Mass Notification Systems

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## SECTION 27 53 13 13 - CLOCK AND PROGRAM CONTROL

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for clock and program control. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
2. Master clock and program control unit.
3. Secondary indicating clocks.
4. Program signal devices.
5. Clock circuit power boosters.
6. Interface with intercom and public-address system.
7. System wire and cable.

#### C. Definitions

1. NIST: The National Institute of Science and Technology.
2. PC: Personal computer.
3. UTC: Universal time coordinated. The precisely measured time at zero degrees longitude; a worldwide standard for time synchronization.

#### D. Performance Requirements

1. Seismic Performance: Master clock and housing shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
2. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes (including available colors) for each product indicated and describe features and operating sequences, both automatic and manual.
2. Shop Drawings: For clock systems. Include plans, elevations, sections, details, and attachments to other work.
  - a. Wiring Diagrams: For power, signal, and control wiring and correction circuits.
    - 1) Identify terminals and wiring color codes to facilitate installation, operation, and maintenance.
    - 2) Indicate recommended wire types and sizes, and circuiting arrangements for field-installed system wiring. Show protection from overcurrent, static discharge, and voltage surge.
  - b. Details of seismic restraints including mounting, anchoring, and fastening devices for the following system components:
    - 1) Surface-mounted and semirecessed secondary indicating clocks.
    - 2) Master clock enclosures **OR** mounting racks, **as directed**.
    - 3) Clock circuit power boosters.
  - c. Details of seismic strengthening of master clock enclosures **OR** mounting racks, **as directed**.



- d. Dimensioned Outline Drawings of the Mounting Rack for the Master Clock: Show internal seismic bracing, and locate center of gravity of fully equipped and assembled unit. Locate and describe mounting and anchorage provisions.
3. Delegated-Design Submittal: For the master clock and housing indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Detail fabrication and assembly of the master clock and housing.
  - b. Design Calculations: Calculate requirements for selecting seismic restraints.
4. Seismic Qualification Certificates: For the master clock, accessories, and components, from manufacturer.
5. Field quality-control reports.
6. Operation and maintenance data.

F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NFPA 70.

## 1.2 PRODUCTS

A. Master And Secondary Clock System

1. System Functions and Features:
  - a. Supply power to remote indicating clocks except those indicated to have correction signals applied through a data circuit.
  - b. Maintain correct synchronized time and transmit time-correction signals over dedicated system wiring from a master clock to any one **OR** two, **as directed**, type(s) of secondary indicating clocks, including the following:
    - 1) Analog Synchronous Clocks: Correct for minute- and second-hand synchronization at least once each hour and for hour-hand synchronization at least once each day.
    - 2) Digital Clocks: Test clocks automatically for synchronization with master time control at least once every hour and automatically correct those not synchronized with the time reference unit. Automatically correct clocks immediately when power is restored after an outage of power to the master clock.
  - c. Initiate and execute programs for scheduled automatic operation of remote devices. Include audible signal devices and visual signal devices, **as directed**, and on and off switching of equipment and circuits, **as directed**.
  - d. Provide for manual control of programmed signal and equipment-switching circuits.
  - e. Communicate with remote PC for access to UTC time base and to permit programming from remote location, **as directed**.
  - f. Maintain system access security with a minimum of one level **OR** two levels **OR** three levels, **as directed**, of user-access control to restrict use of system controls to authorized personnel. Levels of access apply to both local access and access from a remote computer, **as directed**. Access to user programming and control functions is accomplished by entering a minimum three-digit code. Access levels include the following:
    - 1) Access to review existing programs only.
    - 2) Access to normal system operating controls.
    - 3) Access to all user-programming and control functions.
  - g. Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator.  
**OR**  
 Regulate system timing functions using power-line frequency, backed up for power outages by an internal battery-powered, crystal-controlled oscillator, and automated periodic reference to NIST or UTC time signals via internal telephone modem and automatic dialup connection **OR** internal modem and network or microcomputer Internet

access **OR** dedicated internal radio receiver tuned to NIST time signal broadcasts, **as directed**. Reference time signals shall be automatically accessed at programmable intervals.

- h. Provide for programming multiple independent event schedules into memory and running them simultaneously for different output circuits.
  - 1) Quantity of Programmable Schedules: Three **OR** Four **OR** Eight **OR** 18 **OR** 250, **as directed**, minimum.
  - 2) Number of Weekly Events That Can Be Programmed for Each Schedule: 64 **OR** 128 **OR** 300 **OR** 600 **OR** 2500, **as directed**, minimum.
  - 3) Simultaneous operation of independent schedules shall be limited only by the number of signal-device and equipment-switching output circuits.
  - 4) Advance Programming for Automatic Holiday Schedule Changes: Number of schedule changes that can be programmed to suit holidays and vacations shall be 10 **OR** 16 **OR** 50 **OR** 100, **as directed**, and each change may be programmed up to a year in advance to occur on any day of the calendar year.
- i. Automatically check functioning of LEDs, switches, input keys, central processor, read-only memory, random access memory, and output circuits. A display on the control panel or a remote computer with the proper access code, **as directed**, shall indicate failure by identifying faulty component or circuit and shall recommend corrective action.
- j. Provide manually initiated **OR** programming for automatic, **as directed**, daylight savings time correction.
- k. Provide for adjustments to master clock output signals. Duration of momentary signal shall be individually programmable for each signal and equipment-control output circuit from 1 to 99 seconds. Signals shall be programmable for either on or off switching to suit equipment-operation scheduling.

B. Master Clock

- 1. Description: Microprocessor-based, software-controlled unit complying with Class A device requirements in 47 CFR 15.
  - a. Programming and control switches.
  - b. Informational Display: LED or backlit LCD type.
    - 1) Normally shows current time, date, and day of week, **as directed**, display.
    - 2) Provides programming cues when system is being programmed.
  - c. Output Circuits for Power and Correction of Secondary Indicating Clocks:
    - 1) Wired Synchronous Clock Power-and-Correction Circuits: For analog and digital, **as directed**, clocks; a minimum of one **OR** two, **as directed**, required. Relay controlled.  
**OR**  
Wired Synchronous Digital Clock Power-and-Correction Circuits: One, **as directed**, required.
    - 2) Existing Clock Power-and-Correction Circuit: An output circuit suitable for the of existing power-and-correction circuit and number of clocks to be connected.
  - d. Data Output Port for Digital, **as directed**, Secondary Clock Correction Circuit: RS485 or similar circuit for scheduled periodic correction signals.
  - e. Modem and PC interface software suitable for remote programming and automatic NIST or UTC synchronization, **as directed**.
  - f. Circuits for Audible and Visual, **as directed**, Signal Devices: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, five **OR** 10, **as directed**, A minimum. A minimum of two **OR** four **OR** six **OR** eight, **as directed**, circuits.
  - g. Circuits for Programmable Switching of Remote Equipment and Circuits: Relay controlled, manually switchable, using controls on the master clock. Rated 120-V ac, 5 **OR** 10, **as directed**, A minimum. A minimum of two **OR** four **OR** six **OR** eight, **as directed**, circuits.
  - h. Power Supplies: Capacity for internal loads and power-and correction circuits of connected clocks.



- i. Enclosure: Metal cabinet with locking front panel. When cabinet is locked, display indication shall be visible on or through front panel face. Arrange cabinet for surface, semirecessed, or flush mounting as indicated.  
**OR**  
Housing: Rack-mounting metal enclosure with display indication visible on front panel face.
  - 1) Reinforce mounting and attachment capable of resisting seismic forces described in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
- j. Battery Backup for Time Base: Lithium battery to maintain the timekeeping function and retain the programs in memory during outage of normal ac power supply for up to 10 years.
- k. Electrostatic Discharge Resistance: Master clock and secondary indicating clocks, **as directed**, shall be tested and certified according to IEC 61000-4-2 in both human-discharge and direct-injection modes.

C. Secondary Indicating Clocks

- 1. Analog Clock: Equipped with a sweep second hand. Movement shall be driven by self-starting, permanently lubricated, sealed synchronous motor equipped with a correcting solenoid actuator, or be a microprocessor-based, second impulse unit, compatible with the master clock.
- 2. Digital Clock: Microprocessor-controlled unit complying with Class A device requirements in 47 CFR 15, with red LED digital time display of hours and minutes **OR**, minutes, and seconds, **as directed**.
  - a. Display Height: 2-1/2-Inch (64-mm) Clock: Hour and minute numerals readable at 50 feet (15 m).  
**OR**  
Display Height: 4-Inch (102-mm) Clock: Hour and minute numerals readable at 100 feet (30 m).
  - b. Display Format: Selectable between 12-hour with "PM" LED display and 24-hour formats.
  - c. Connections for Power and Correction:
    - 1) Wired synchronous connection to the master clock for both operating power and correction.
      - a) Time-Base Backup: Internal alkaline battery shall back up internal time base to maintain timekeeping during power outages of up to six days' duration.  
**OR**  
Time-Base Backup: Internal capacitor shall back up internal time base to maintain timekeeping during power outages of up to 12 hours' duration.
      - b) Correction by RS485, Ethernet, or similar data line with operating power supplied over a separate connection.
      - c) Power Connection for Secondary Indicating Clocks: Plug connector **OR** Wire pigtail or compression splice, **as directed**.
- 3. Interval-Timer Clock: Digital microprocessor-controlled, 4-inch (102-mm) unit with 2-1/2-inch (64-mm), red LED digital display for hours and minutes and 1-5/16-inch (33-mm) display for seconds; a separately mounted, mode-control switch; and the following features:
  - a. Display Visibility: Hour and minute numerals readable at 30 feet (10 m) in normal ambient light.
  - b. Operating Modes:
    - 1) Normal: Clock operates as a regular secondary system clock, displaying corrected time in normal display configuration, selectable between 12- and 24-hour formats, with "PM" digital display for 12-hour format.
    - 2) Count-Down or Count-Up Timer: Selected by mode-control switch count-up and count-down positions, and capable of being preset at the mode-control station.
    - 3) Code Blue: Automatically selected by a signal through a wiring connection from the code-blue system. This signal captures control of the clock regardless of current mode or correction status and instantly initiates count-up operation, starting at time 00:00:00. While in this mode, other clock functions, including correction, shall run in

- the background. Clock shall revert to normal operating mode when the initiating-signal system is reset.
- c. Mode-Selector Switch: Push-button or rotary, multiposition type, flush mounted; with start, stop, and reset capability in both count-up and count-down modes.
  - d. Audible tone signal: Housed in clock or mode-selector-switch box. Sounds at end of preset up or down count.
4. Provision for Modular Panel Installation: Equip designated clock for panel mounting. Mount flush or semirecessed with arrangement and trim as indicated. Coordinate wiring with other modular panel components, including room lighting switches **OR** intercom devices **OR** convenience outlets **OR** data outlets **OR** speaker **OR** other similar devices, **as directed**.
  5. Provision for Time-Tone-Unit Installation: Equip indicated clocks for housing or mounting in an acoustically treated and baffled speaker compartment specified in Division 27 Section "Public Address And Mass Notification Systems".
- D. Secondary Indicating Clock Characteristics:
- a. Clock Type: Analog **OR** Digital, **as directed**.
  - b. Face Configuration: Single **OR** Double, **as directed**.
  - c. Mounting: Recessed **OR** Semirecessed **OR** Pendant **OR** Surface **OR** Suspended **OR** Within time-tone unit **OR** Within modular panel, **as directed**.
  - d. Nominal Dimensions: as directed by the Owner.
  - e. Casing Finish: Types and colors, as directed by the Owner.
  - f. Special Environmental Conditions: Describe conditions such as corrosive, damp, or wet locations, as directed by the Owner.
  - g. For analog clocks.
    - 1) Dial Face Color: as directed by the Owner.
    - 2) Analog Clock Crystal: Clear glass **OR** acrylic **OR** polycarbonate, **as directed**.
  - h. For digital clocks.
    - 1) Face Color: as directed by the Owner.
    - 2) Display Height: as directed by the Owner.
    - 3) Seconds Display: Yes **OR** No, **as directed**.
    - 4) Digital Clock Lens: Antiglare acrylic material.
    - 5) Battery Backup: Yes **OR** No, **as directed**.
    - 6) Interval-Timer Display: Yes **OR** No, **as directed**.
- E. Program Signal Devices
1. Bells: Heavy-duty, modular, vibrating type with the following sound-output ratings measured at 10 feet (3 m):
    - a. 4-Inch (100-mm) Bell: 90 dB.
    - b. 6-Inch (150-mm) Bell: 95 dB.
    - c. 10-Inch (250-mm) Bell: 104 dB.
  2. Chimes: Heavy-duty, modular, vibrating chimes with polished-chrome tone bar and enamel-finished housing. Minimum sound-output rating measured at 10 feet (3 m) shall be 75 dB.
  3. Clock Buzzers: Adjustable output signal device designed for mounting within clock housing or outlet box.
    - a. Sound-Output Rating Measured at 3 Feet (1 m): 75 dB.
    - b. Audible Tone Frequency: Manufacturer's standard between 120 Hz and 2 kHz.
  4. Horns: Modular, adjustable-output, vibrating type with minimum full-intensity-rated sound output of 103 dB measured at 10 feet (3 m).
  5. Projector Horns: Adjustable-output, vibrating type with single **OR** double, **as directed**, projector arranged to channel sound in the direction of the projector axis, and with minimum full-intensity-rated sound output of 104 dB measured at 10 feet (3 m).
  6. Loudspeakers for Audible Tones: See Division 27 Section "Public Address And Mass Notification Systems".
  7. Visible Signal Devices: Strobe lights with blue **OR** yellow, **as directed**, polycarbonate lens and xenon flash tube, with lens mounted on an aluminum faceplate and the word "Program" engraved





in letters at least 1 inch (25 mm) high on lens. Lamp unit shall have a minimum rated light output of 75 candela.

8. Combination Audible and Visible Signal Devices: Factory-integrated horn and strobe light in a single mounting assembly.
9. Outdoor Signal Equipment: Weatherproof models listed for outdoor use.
10. Mounting Arrangement for Signal Devices: Designed for attachment with screws on the mounting plate of a flush-mounted back box unless otherwise indicated.
11. Enclosures for Flush-Mounting Bells and Horns: Enclosure, mounting plate, and grille assembly shall be furnished by device manufacturer to match features of the device to be mounted. Enclosure shall be recessed in wall, completely enclosing the device, with grille mounting over the open side of the enclosure and flush with the wall.
12. Connection Provision for Signal-Indicating Devices: Plug connector **OR** Wire pigtail or compression splice, **as directed**.

F. Clock Circuit Power Booster

1. Description: Transformer power supply, mounted in steel cabinet with hinged door, and having fuse-protected input and output circuits.

G. Back Boxes For Secondary Indicating Clocks And Program Devices

1. Description: Box and cover-plate assembly shall be furnished by device manufacturer and be suitable for device to be mounted. Back boxes shall be equipped with knockouts and hanger straps or mounting adapters arranged for flush mounting the device unless otherwise indicated.

H. Guards

1. Description: Formed-steel wire, shaped to fit around guarded device, with 1-inch (25-mm) maximum clearance.
  - a. Mounting Provisions: Fixed tabs, welded to guard and arranged for screw attachment to mounting surface.
  - b. Finish for Indoor Devices: Clear epoxy lacquer over zinc plating.
  - c. Finish for Outdoor Devices: Black powder coat over zinc plating and primer.

I. Rack-Mounting Provision For Master Clock

1. Equipment Cabinet: Floor **OR** Wall, **as directed**, -mounted, rack type. Comply with EIA-310-D and the following:
  - a. Cabinet Housing: Constructed of steel, with front and rear, **as directed**, doors; with manufacturer's standard tumbler locks, keyed alike.
    - 1) Front door shall have a clear panel in front of the master clock display.
    - 2) Housing shall enclose master clock and auxiliary clock system components, plus a minimum of 20 percent spare capacity for future equipment.
  - b. Forced Ventilation: Internal low-noise fan with a filtered intake vent, connected to operate from 105- to 130-V ac, 60 Hz; separately fused and switchable and arranged to be powered when main cabinet power switch is on.  
**OR**  
Natural Ventilation: Ventilated rear and sides with louvers and solid top.
  - c. For freestanding, floor-mounting cabinet, arrange inputs, outputs, interconnections, and test points so they are accessible at rear of rack for maintenance and testing, with each item removable from rack without disturbing other items or connections.
  - d. Blank Panels: Cover empty space in equipment racks so entire front of rack is occupied by equipment or panels.
  - e. Finish: Uniform, baked-enamel, manufacturer's standard color finish over rust-inhibiting primer.
  - f. Power-Control Panel: On front of equipment housing; with master power on-off switch and pilot light, and socket for a 5-A, indicating, cartridge fuse for rack equipment power.
  - g. Vertical Plug Strip: Grounded receptacles, 12 inches (300 mm) o.c. the full height of rack, to supply rack-mounting equipment.

- h. Maintenance Receptacles: Duplex convenience outlet with supply terminals separate from equipment plug strip and located in front of rack.

J. Conductors And Cables

1. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper. Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG. Voltage drop for signal, control, and clock correction circuits shall not exceed 10 percent under peak load conditions. Comply with requirements in Division 27 Section "Communications Horizontal Cabling".
2. 120-V AC and Class 1 Signal and Control Circuits: Stranded, single conductors of size and type recommended by system manufacturer. Materials and installation requirements are specified in Division 26 Section "Low-voltage Electrical Power Conductors And Cables".
3. Class 2 and Class 3 Signal and Control Circuits: Single conductor or twisted-pair cable, unshielded, unless manufacturer recommends shielded cable.
4. Data Circuits: Category 6 minimum, unshielded, twisted-pair cable, unless manufacturer recommends shielded cable.
5. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.
6. Plenum Cable: Listed and labeled for plenum installation.
7. Conductor Color-Coding: Uniformly identified and coordinated with wiring diagrams.
8. Shielding: For speaker-microphone leads and at other locations recommended by manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or equivalent foil.
  - a. Minimum Shielding Coverage on Conductors: 60 percent.

K. Pathways

1. Intercommunication and Program System Raceways and Boxes: Comply with requirements in Division 26 Section "Raceway And Boxes For Electrical Systems".  
**OR**  
Intercommunication and Program System Raceways and Boxes: Same as required for electrical branch circuits specified in Division 26 Section "Raceway And Boxes For Electrical Systems".  
**OR**  
Intercommunication and Program System Raceways and Boxes: Optical fiber/communications raceway and fittings **OR** Metal wireways **OR** Nonmetal wireways **OR** Surface metal raceways **OR** Surface nonmetal raceways, **as directed**.
2. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.
3. Flexible metal conduit is prohibited.

1.3 EXECUTION

A. Installation

1. Mount system components with fastening methods and devices designed to resist the seismic forces indicated in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".

B. Wiring Methods

1. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.
  - a. Install plenum cable in environmental air spaces, including plenum ceilings.
  - b. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway And Boxes For Electrical Systems".**OR**  
Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.



2. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
  3. Support cables not enclosed in raceways on J-Hooks. Install, size, and space J-Hooks to comply with TIA/EIA-568-B.
- C. Electrical Connections
1. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
  2. Use plug connectors **OR** splices, **as directed**, for connections to clocks and signal devices.
  3. Ground clocks, programming equipment, and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Identification
1. Comply with Division 26 Section "Identification For Electrical Systems".
  2. Color-code wires, and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.
- E. Field Quality Control
1. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
  2. Tests and Inspections:
    - a. Perform operational-system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all modes of clock correction and all programming and manually programmed signal and relay operating functions.
    - b. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
  3. Clock system will be considered defective if it does not pass tests and inspections.
  4. Prepare test and inspection reports.
- F. Adjusting
1. Program system according to the Owner's requirements. Set system so signal devices operate on the Owner-required schedules and are activated for durations selected by the Owner. Program equipment-control output circuits to suit the Owner's operating schedule for equipment controlled.
  2. Adjust sound-output level of adjustable signal devices to suit the Owner's requirements.
  3. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
- G. Demonstration
1. Train the Owner's maintenance personnel to adjust, operate, and maintain clock-and-program-control system components.

END OF SECTION 27 53 13 13



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Task	Specification	Specification Description
27 53 13 16	27 53 13 13	Clock And Program Control

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## SECTION 28 16 11 00 - PERIMETER SECURITY

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for perimeter security. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Perimeter detection and alarm system.
  - b. Integration of other electronic and electrical systems and equipment.

#### C. Definitions

1. CCTV: Closed-circuit television.
2. EMI: Electromagnetic interference.
3. PIR: Passive infrared.
4. RFI: Radio-frequency interference.
5. UPS: Uninterruptible power supply.
6. Control Unit: System component that monitors inputs and controls outputs through various circuits.
7. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.
8. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
9. Protected Zone: A protected premises or an area within a protected premise that is provided with means to prevent an unwanted event.
10. Standard Intruder: A person who weighs **100 lb (45 kg)** or less and whose height is **60 inches (1525 mm)** or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.
11. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.
12. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
13. Zone: A defined area within a protected premise. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

#### D. Action Submittals

1. Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: Detail assemblies of standard components that are custom assembled for specific application on this Project.
  - a. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers **OR** networks, **as directed**, and control interface devices and media to be used. Describe characteristics of network and other data communication lines.



- 1) Indicate methods used to achieve systems integration.
  - 2) Indicate control, signal, and data communication paths and identify PLCs, networks, control interface devices, and media to be used.
  - 3) Describe characteristics of network and other data communication lines.
  - 4) Describe methods used to protect against power outages and transient voltages including types and ratings of isolation and surge suppression devices used in data, communication, signal, control, and ac and dc power circuits.
  - b. Raceway Riser Diagrams: Detail raceway runs required for perimeter security and for systems integration. Include designation of devices connected by raceway, raceway type, and size, and type and size of wire and cable fill for each raceway run.
  - c. UPS: Sizing calculations.
  - d. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for central-station control-unit console, terminal cabinet, racks, and UPS.
  - e. Master Control Unit Console Layout: Show required artwork and device identification.
  - f. Device Address List: Coordinate with final system programming.
  - g. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
  - h. Details of surge-protection devices and their installation.
  - i. Sensor detection patterns and adjustment ranges.
  3. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are not acceptable.
  4. Samples for Initial Selection: For units with factory-applied color finishes.
  5. Samples for Verification: For each type of exposed finish required.
- E. Informational Submittals
1. Qualification Data: For Installer, security systems integrator, and testing agency.
  2. Field quality-control test reports.
  3. Warranty: Sample of special warranty.
  4. Other Information Submittals:
    - a. Test Plan and Schedule: Test plan defining all tests required to ensure that system meets technical, operational, and performance specifications within 60 days of date of Contract award.
    - b. Examination reports documenting inspections of substrates, areas, and conditions.
    - c. Anchor inspection reports documenting inspections of built-in and cast-in anchors.
- F. Closeout Submittals
1. Operation and Maintenance Data: For perimeter security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation And Maintenance Data", include the following:
    - a. Data for each type of product, including features and operating sequences, both automatic and manual.
    - b. Master control-unit hardware and software data.
- G. Maintenance Material Submittals
1. One spare control-unit board(s) for strain-sensitive cable system and one cable repair and splice kit(s).
  2. One of each type of microwave sensor and one of each type of power supply for microwave perimeter security system.
  3. One of each spare sensor and PIR unit and one alignment telescope(s) for long-range PIR system.
  4. One spare control-unit board(s) for electrostatic-field system.

5. One spare control-unit board(s) for buried, ported coaxial cable system, **10 feet (3 m)** of cable; and one cable repair and splice kit(s).
6. Fuses: Three of each kind and size.
7. Tool Kit: Provide six sets of tools for use with security fasteners, each packaged in a compartmented kit configured for easy handling and storage.
8. Security Fasteners: Furnish no fewer than 1 box for every 50 boxes or fraction thereof, of each type and size of security fastener installed.

H. Quality Assurance

1. Installer Qualifications:
  - a. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association.
  - b. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
2. Security Systems Integrator Qualifications: An experienced perimeter security equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
3. Testing Agency Qualifications: Member company of NETA or an NRTL.
  - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. FMG Compliance: FMG-approved and -labeled perimeter security devices and equipment.
6. Comply with NFPA 70.

I. Project Conditions

1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
  - a. Altitude: Sea level to **4000 feet (1220 m)**.
  - b. Master Control Unit: Rated for continuous operation in an ambient of **60 to 85 deg F (16 to 29 deg C)** and a relative humidity of 20 to 80 percent, noncondensing.
  - c. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of **minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to **85 mph (137 km/h)** and snow cover up to **24 inches (610 mm)** thick.
  - d. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

J. Warranty:

1. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of perimeter security devices and equipment that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period: Two years from date of Final Completion.

## 1.2 PRODUCTS

A. Functional Description Of System

1. Description: Perimeter protection system with fence-mounted systems **OR** buried sensors **OR** volumetric detectors, **as directed**, integrated into a single perimeter detection and alarm system.
2. Supervision: System components shall be continuously monitored for normal, alarm, supervisory and trouble conditions. Indicate deviations from normal conditions at any location in





system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.

- a. Alarm Signal: Display at central-station control unit and actuate audible and visual alarm devices.
  - b. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or controller failure.
  - c. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or controller.
3. System Control: Central-station control unit shall directly monitor gate detection devices, perimeter detection units, and connecting wiring.

**OR**

System Control: One or more remote, addressable controllers operate under control of a central-station control-unit microcomputer in a multiplexed distributed control system or as part of a network. Controllers shall receive programming by multiplexed signal transmission from a central-station control-unit microprocessor or microcomputer and hold data in nonvolatile memory. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance, **as directed**.

4. Operator Commands:
  - a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
  - b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
  - c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
  - d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
  - e. Protected Zone Test: Initiate operational test of a specific protected zone.
  - f. System Test: Initiate system-wide operational test.
  - g. Print Reports.
5. Timed Control at Central-Station Control Unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
6. Automatic Control of Related Systems: Alarm or supervisory signals from certain perimeter security devices control the following functions in related systems:
  - a. Switch selected lights.
  - b. Open a signal path between certain intercommunication stations.
  - c. Shift sound system to "listening mode" and open a signal path to certain system speakers.
  - d. Switch signal to selected monitor from closed-circuit television camera in vicinity of sensor signaling an alarm.
7. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When central-station control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
8. Response Time: Two seconds between actuation of any alarm and its indication at central-station control unit.
9. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, controllers, and sensors from central-station control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at central-station control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.

10. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.
  11. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.
- B. System Component Requirements
1. Compatibility: Detection devices and their communication features, connecting wiring, and master control unit shall be selected and configured with accessories for full compatibility with the existing equipment.
  2. Perimeter Security Units: Listed and labeled by a qualified testing agency for compliance with UL 639.
  3. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
    - a. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
    - b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
  4. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V RMS injected into power supply lines at 10 to 10,000 MHz.
  5. Tamper Protection: Tamper switches on detection devices, controllers, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Central-station control-unit alarm display shall identify tamper alarms and indicate locations.
  6. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to central-station control unit.
  7. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to central-station control unit as an alarm signal.
  8. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to central-station control unit.
  9. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at central-station control unit for calibration, sensitivity, and alarm condition.
- C. Enclosures
1. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
  2. Interior Electronics: NEMA 250, Type 12.
  3. Exterior Electronics: NEMA 250, Type 4X fiberglass **OR** stainless steel, **as directed**.
  4. Corrosion Resistant: NEMA 250, Type 4X PVC **OR** stainless steel, **as directed**.
  5. Terminal cabinets in handholes and manholes shall be NEMA 250, Type 6 **OR** 6P, **as directed**.
  6. Screw Covers: Where enclosures are accessible to inmates, secure with security fasteners of type appropriate for enclosure.
- D. Secure And Access Devices
1. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.



2. Key-Operated Switch: Change protected zone between secure and access conditions.

E. Strain-Sensitive Cable

1. Description: Strain-sensitive, coaxial transducer cable shall monitor chain-link-type and welded-mesh-type fence and generate an alarm when a standard intruder attempts to climb over, cut through, or lift fence fabric.
2. Environment: Suitable for exterior installation and the following conditions:
  - a. Ambient Temperatures: Ranging from **minus 22 to plus 158 deg F** (**minus 30 to plus 70 deg C**).
3. Transducer Cable:
  - a. Ultraviolet-resistant cable furnished by system manufacturer.
  - b. Suitable for up to **1000 feet (300 m)** of sensor cable per single-zone controller and up to **2000 feet (600 m)** of sensor cable per dual-zone processor.
  - c. Sensitivity shall be uniform throughout its entire length, requiring only one variable sensitivity adjustment throughout its entire length.
4. Control Unit:
  - a. Field mounted, with tamper switch at controller board.
  - b. Electronic circuitry shall discriminate between acceptable fence movement and intrusion-related disturbances.
  - c. Sensitivity, count control, and climb-over processors shall be adjustable with a minimum of five individual count-control and climb-over adjustments.
  - d. Controller output shall have adjustable pulse width to adjust the time the alarm relay will activate per detected intrusion attempt.
5. System Performance:
  - a. Immune to RFI and EMI environments; interference shall have no effect on normal operational characteristics.
  - b. Trouble and Tamper: Entire sensor system shall be fully supervised with individually monitored tamper and supervision alarms. Disconnecting, cutting, or shorting of strain-sensitive cable results in supervisory alarm.
  - c. Intrusion Simulation: Each zone shall have a self-test feature that, when activated by a signal from central-station control unit, will produce an intrusion alarm and verify operation of sensor.

F. Microwave Intrusion Detectors

1. Description: Volumetric microwave detection system.
2. Device Performance: Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
  - a. Movement Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between **0.1 to 50 fps** (**0.03 to 15.2 m/s**). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
  - b. Detection range: **15 to 600 feet (5 to 180 m)**.
  - c. Range Sensitivity: Adjustable for setting area of protection between **15 to 500 feet (5 to 152 m)** in range and from **2 to 40 feet (0.6 to 12 m)** in beam diameter.
  - d. Trouble and Tamper: Fully supervised with individually monitored tamper and supervision alarms. System failure shall result in tamper alarm. System jamming or wrong modulation shall result in supervisory alarm.
  - e. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.
  - f. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.
3. Environment: Suitable for exterior installation and the following conditions:

- a. Ambient Temperatures: Ranging from minus 30 to plus 158 deg F (minus 34 to plus 70 deg C) and in rainfall up to 4 inches (100 mm).
- G. Electrostatic Field
1. Description: Electronically balanced phase electrostatic-field detection system consisting of a field generator that generates an electrical field in one or more field wires and that has two or more sensing wires, a sense filter, amplifier, and a controller. Detection fields shall have a minimum of four different frequencies so adjacent zones cannot interfere with each other.
  2. Environment: Suitable for exterior installation and the following conditions:
    - a. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).
  3. System Performance:
    - a. Detect, via sense wires, a compound signal form consisting of amplitude change, rate of change, and pre-set time disturbance that forms a "signature" of human movement. Generate an alarm when all exist simultaneously. Provide detection fields of not less than four different frequencies so adjacent zones do not interfere with each other.
    - b. Control Units: Single or multiple zone, with sense filter. Front panel with calibration meter, status of alarm transmitter, sensitivity selector, test point selector, power indicator, and power control. Control unit shall reject signals due to wind and small objects striking the wires.
    - c. Motion Detection: Sense standard-intruder movement at rates from 0.15 to 26 fps (0.045 to 8.0 m/s).
    - d. Zone Length: Not to exceed 500 feet (152 m) OR 325 feet (100 m), as directed.
    - e. Supervision: Generate trouble signal if field or sense wires are cut or shorted to ground or to each other. Generate supervisory alarm if received signal is substantially reduced.
  4. Insulators, Wire-Tensioning Devices, and Brackets: Manufacturer's standard for mounting and tensioning of wires.
  5. Field and Sensing Wires: Stainless steel.
- H. Buried, Ported Coaxial Cable
1. Description: Buried electrostatic-field detection system consisting of parallel, ported coaxial cables that generate a detection field between cables.
  2. Environment: Suitable for exterior installation and the following conditions:
    - a. Ambient Temperatures: Ranging from minus 22 to plus 158 deg F (minus 30 to plus 70 deg C).
  3. System Performance: One of two parallel cables receives a continuous wave signal from a transmitter module. Second cable, connected to a sensor module, detects, preamplifies, and analyzes variations in signal. When system senses "signature" of a standard intruder in the detection zone, based on mass, motion, and time of day, it generates an alarm.
    - a. Transmitter: Locate at one end of zone, with standby battery.
    - b. Preamplifier-Sensor: Locate at opposite end from transmitter, with standby battery.
    - c. Front panel with sensitivity calibration meter, calibrated self-test potentiometer, power switch, and LED normal and malfunction indicators.
    - d. Electromagnetic Radiation: Less than 50 mV per meter at 30 m.
    - e. Motion Detection: Sense standard-intruder movement at rates from 0.17 to 26 fps (0.05 to 8.0 m/s).
    - f. Zone Length: Not to exceed 500 feet (152 m) OR 325 feet (100 m), as directed.
    - g. Zone Width: Not to exceed 15 feet (4.6 m), with an average width of 12 feet (3.7 m).
    - h. Zone Height: Approximately 3.3 feet (1.0 m), depending on sensitivity setting.
    - i. Supervision: Generate trouble signal if cable is cut or shorted to ground. Generate supervisory alarm if cabinets are tampered with.
  4. Enclosures: Hinged cover with tamper switch and security fasteners.
  5. Buried, Ported Coaxial Cable: Approximately 1/2-inch (1.3-mm) diameter, minimum 10 AWG center conductor, foam polyethylene dielectric, braided copper outer conductor, and polyethylene jacket.



- I. Long-Range PIR Detectors
1. Description: Volumetric passive infrared detection system.
  2. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.
  3. Environment: Suitable for exterior installation and the following conditions:
    - a. Ambient Temperatures: Ranging from **minus 30 to plus 150 deg F** (**minus 34 to plus 65 deg C**).
  4. System Performance: Detect an interruption of dual-infrared light beams that link transmitters and receivers. Generate an alarm when signal is interrupted due to presence of an object that interrupts both beams.
    - a. Sensitivity: Field adjustable to allow adjustment of range from **25 to 500 feet** (**7.6 to 152 m**), generating an alarm within 20 to 50 ms when both beams are interrupted.
    - b. Detection system shall adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
    - c. Motion Detection: Detect standard-intruder movement at rates from **0.1 to 50 fps** (**0.03 to 15.2 m/s**).
    - d. Supervision: Generate supervisory alarm if any portion of system is tampered with.
    - e. Remote Test: When initiated by central-station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.
- J. Geophone Fence Detection
1. Description: Fence-mounted system to detect attempts to cut or climb the protected fence, using geophone sensors that respond to specific shock or vibrations.
  2. Environment: Suitable for exterior installation and the following conditions:
    - a. Ambient Temperatures: Ranging from **minus 30 to plus 150 deg F** (**minus 34 to plus 65 deg C**).
  3. System Performance:
    - a. Controller: 10 zone capacity for processing geophone generated analog signals. Each zone shall consist of not more than 10 sensors.
      - 1) Adjustments: For each zone provide stepped gain control for sensitivity, and switches for geophone signal filters to minimize nuisance alarms. System shall adjust automatically to compensate for weather, including fog, rain, snow, blowing dust, and rapid temperature changes.
      - 2) Trouble Condition Signal: Generate when any zone fails.
      - 3) Supervisory Condition Signal: Generate on interference with controller operation or when detecting a break-in into a enclosure housing electronics.
    - b. Sensors: Fence mounted **20 feet** (**6 m**) o.c.
    - c. Cable for Interconnection of System Components: Shielded, PVC jacketed and armored, as supplied by system manufacturer.
    - d. Test each zone simulating an alarm condition. Test by command from central-station control **OR** test switch at controller inside the enclosure, **as directed**.
- K. Video Motion Sensor
1. Description: Video-surveillance based detection system.
  2. Device Performance: Detect changes in video signal within a user-defined protected zone. Provide an alarm output for each video input.
    - a. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
    - b. Modular design that allows for expansion or modification of number of inputs.
    - c. Adjustable Controls:
      - 1) Number of detection zones.
      - 2) Size of detection zones.
      - 3) Sensitivity of detection of each protected zone.
    - d. Mounting: Standard **19-inch** (**480-mm**) rack as described in EIA 310.

3. Environment: Suitable for installation in interior air-conditioned spaces.

L. Gate Units

1. Description: Fence mounted gate-movement detector, blanced-magnetic type, UL listed for outdoor locations. Units shall be designed for mounting on single- or double-leaf swinging or rolling gates and have armored jumper cables between switch and stationary junction box for wiring to central-station control unit and tamper switches in junction box.
2. Device Performance: Bias magnet and at least three encapsulated-reed switches that resist compromise from introduction of foreign magnetic fields, with integral overcurrent protective device to limit current to 80 percent of switch capacity.
3. Remote Test: Simulate movement of actuating magnet from central-station control unit.

M. Field-Mounted Control Units

1. Field-mounted control units shall include the power supply and detector specific functions, and provide for communications with the master control unit. Control unit shall include read-only resident software needed for startup, a time clock, and all automatic operations. Software shall be downloaded from the master control unit.
2. Battery Backup: UPS, providing 6 hours of run time during a power outage, with 2-rate automatic battery charger to fully recharge batteries within 12 hours after normal power is restored.
  - a. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy.
  - b. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.
3. Annunciation: Indicate a change in system condition and switching of system or component to backup power.

N. Master Control Unit

1. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
  - a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
  - b. Include a real-time clock for time annotation of events on the event recorder and printer.
  - c. Addressable initiation devices that communicate device identity and status.
  - d. Control circuits for operation of mechanical equipment in response to an alarm.
2. Construction: Freestanding equipment rack **OR** Desk-mounted console, **as directed**, modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.
3. Comply with UL 609 **OR** UL 681 **OR** UL 1076, **as directed**.
4. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
  - a. Annunciator and Display: LCD type, one **OR** two **OR** three line(s) of 40 **OR** 80 characters, minimum, **as directed**.
  - b. Keypad: Arranged to permit entry and execution of programming, display, and control commands
  - c. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display and at the system printer.
  - d. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of





- field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.
- e. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
    - 1) Acknowledge alarm.
    - 2) Silence alarm.
    - 3) System reset.
    - 4) LED test.
  - f. Timing Unit: Solid state, programmable, 365 days.
  - g. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
  - h. Alarm Indication: An audible signal sounds and an LED lights at master control unit identifying the protected zone **OR** addressable detector, **as directed**, originating the alarm. Annunciator panel displays a common alarm light and sounds an audible tone.
  - i. Alarm Indication: An audible signal sounds and a plain-language identification of the protected zone **OR** addressable detector, **as directed** originating the alarm appears on LED or LCD display at master control unit. Annunciator panel displays a common alarm light and sounds an audible tone.
  - j. Alarm Indication: An audible signal sounds and a plain-language identification of the protected zone **OR** addressable detector, **as directed** originating the alarm appears on LED, LCD or cathode-ray-tube display, **as directed** at master control unit. Annunciator panel alarm light and audible tone identify protected zone signaling an alarm.
  - k. Alarm activation sounds a bell **OR** siren **OR** strobe **OR** bell or siren and strobe, **as directed**.
5. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.
  6. Power Supply Circuits: Master control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.
  7. UPS: Comply with Division 26 Section "Static Uninterruptible Power Supply". UPS shall be sized to provide a minimum of six hours of master control-unit operation.
  8. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than **1 inch (25 mm)** high. Identify, with permanent labels, individual components and modules within cabinets.
  9. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.
  10. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

O. Audible And Visual Alarm Devices

1. Bell: UL listed, **10 inches (254 mm)** in diameter, rated to produce a minimum sound output of 84 dB at **10 feet (3 m)** from central-station control unit.
  - a. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.

2. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at **3 feet (1 m)**, plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use - two minutes on, five minutes off.
  - a. Designed for use in industrial areas and in high noise, severe weather marine environments.
3. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at **10 feet (3 m)** from central-station control unit.
  - a. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
4. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
  - a. Light Output: 115 cd, minimum.
  - b. Flash Rate: 60 per minute.

P. Security Fasteners

1. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
2. Drive System Types: Pinned Torx-Plus, pinned Torx, or pinned hex (Allen).
3. Socket Flat Countersunk Head Fasteners:
  - a. Heat-treated alloy steel, **ASTM F 835 (ASTM F 835M)**.
  - b. Stainless steel, **ASTM F 879 (ASTM F 879M)**, Group 1 CW.
4. Socket Button Head Fasteners:
  - a. Heat-treated alloy steel, **ASTM F 835 (ASTM F 835M)**.
  - b. Stainless steel, **ASTM F 879 (ASTM F 879M)**, Group 1 CW.
5. Socket Head Cap Fasteners:
  - a. Heat-treated alloy steel, **ASTM A 574 (ASTM A 574M)**.
  - b. Stainless steel, **ASTM F 837 (ASTM F 837M)**, Group 1 CW.
6. Protective Coatings for Heat-Treated Alloy Steel:
  - a. Zinc chromate, ASTM F 1135, Grade 3 or 4; for exterior applications and interior applications where indicated.
  - b. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide, unless otherwise indicated.

Q. Source Quality Control

1. Electrostatic-Field and Buried, Ported Coaxial Cable Systems Electronics: Precondition at factory by subjecting modules to at least 4 days' operational burn-in at temperatures not less than **140 deg F (60 deg C)**.

### 1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of perimeter security.
2. Examine roughing-in for embedded and built-in anchors to verify actual locations of perimeter security connections before perimeter security installation.
3. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of perimeter security.
4. Inspect built-in and cast-in anchor installations, before installing perimeter security, to verify that anchor installations comply with requirements. Prepare inspection reports.
  - a. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.
  - b. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
5. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
6. Proceed with installation only after unsatisfactory conditions have been corrected.



**B. Systems Integration**

1. Integrate perimeter security system with the following systems and equipment:
  - a. Electronic door hardware.
  - b. Elevators.
  - c. Network lighting controls.
  - d. Intercommunications and program systems.
  - e. Public address and mass notification systems.
  - f. Access control.
  - g. Fire-alarm system.
  - h. Intrusion detection system.
  - i. Video surveillance.

**C. System Installation**

1. Comply with UL 681 and NFPA 731.
2. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
  - a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
3. Install wall-mounted equipment, with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
  - a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.
  - a. Connect new equipment to existing control panel in existing part of the building.
  - b. Connect new equipment to existing monitoring equipment at the Supervising Station.
  - c. Expand, modify, and supplement existing **control** or **monitoring** equipment as necessary to extend existing **control** or **monitoring** functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
5. Security Fasteners: Where accessible to inmates, install perimeter security components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.
6. Wiring Method: Install power, signal, and data transmission wire and cable in raceways according to Division 26 Section(s) "Underground Ducts And Raceways For Electrical Systems" AND "Raceway And Boxes For Electrical Systems". Minimum conduit size shall be **1/2 inch (13 mm)**. Control and data transmission wiring shall not share raceways with any other system.
7. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with perimeter security system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
8. Wires and Cables:
  - a. Conductors: Size as recommended in writing by system manufacturer, unless otherwise indicated.
  - b. 120-V Power Wiring: Install according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables", unless otherwise indicated.
  - c. Cable for Low-Voltage Control and Signal Circuits: Install unshielded, twisted-pair cable, unless otherwise indicated or if manufacturer recommends shielded cable, according to Division 28 Section "Conductors And Cables For Electronic Safety And Security".

- d. Data and Television Signal Transmission Cables: Install according to Division 28 Section "Conductors And Cables For Electronic Safety And Security"
  9. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.
  10. Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.
  11. Stain-Sensitive Transducer Cable: Attached to fence at **12-inch (300-mm)** intervals with tie wraps.
  12. Electrostatic-Field System: Install field and sense wires on insulators and standoffs on a fence, wall, or roof. Provide intermediate supports recommended in writing by manufacturer as needed for specified performance.
  13. Buried, Ported Coaxial Cable: Transmitters may be located at one end of parallel coaxial cables, and preamplifier-sensor module may be located at opposite end. Install cable so shield is uniform throughout the length, without twisting or distorting cable during installation. Field-cut cables to exact zone length at the site. To attach data transmission cable to sensing cable, use heat-shrink splice kits approved by manufacturer. Provide sufficient overlap of detector cables to eliminate the possibility of entry between zones.
- D. Identification
1. Identify system components wiring, cabling, and terminals. Comply with identification requirements in Division 26 Section "Identification For Electrical Systems".
  2. Install instructions frame in a location visible from master control unit.
- E. Grounding
1. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
  2. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
  3. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
  4. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".
- F. Field Quality Control
1. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
    - a. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
  2. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections.
  3. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components and equipment installations, including connections.
  4. Tests and Inspections: Comply with provisions in NFPA 731, Ch.9, "Testing and Inspections."
    - a. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
    - b. Operational Tests: Schedule tests after pretesting has been successfully completed. Test all modes of system operation and perimeter security at each detection device. Test for detection of intrusion and for false alarms in each protected zone. Test for false alarms by simulating activities outside indicated detection patterns.
    - c. Electrical Tests: Comply with NFPA 72, Section A-7. Minimum required tests are as follows:



- 1) Verify the absence of unwanted voltages between circuit conductors and ground.
- 2) Test all conductors for short circuits using an insulation-testing device.
- 3) With each circuit pair, short circuit at the far end of circuit and measure circuit resistance with an ohmmeter. Record circuit resistance of each circuit on Record Drawings.
- 4) Verify that each controller is in normal condition as detailed in manufacturer's operation and maintenance manual.
- 5) Test signal and data transmission circuits complying with requirements in Division 28 Section "Conductors And Cables For Electronic Safety And Security" for proper signal transmission under open-circuit conditions. One connection each should be opened at not less than 10 percent of initiating and indicating devices. Observe proper signal transmission according to class of wiring used.
- 6) Verify that transient surge-protection devices are installed according to manufacturer's written instructions.
- 7) Test each initiating and indicating device for alarm operation and proper response at central-station control unit.
- 8) Test both primary and secondary power. Verify, by test, that UPS is capable of operating the system for period and in manner specified.
- d. Geophone System Tests: Test each zone at a minimum of two different locations. Test each zone as follows:
  - 1) Horizontal Movement: Adjust sensitivity to screen out alarms from wind.
  - 2) Vertical Climb: 100 percent detection required. Set count at 3 occurrences within 90-second window.
  - 3) Cut Test: 100 percent detection required. Set count at 2 occurrences within 120-second window.
  - 4) Set sensitivity to value as low as possible, consistent with reliable detection.
  - 5) If performance tests fail, make adjustments to sensors to comply with requirements. Retest failing and adjacent zones to comply with test.
- e. Strain-Sensitive Cable System Tests: Adjust sensitivity and count control to value as low as possible, consistent with reliable detection.
- f. Microwave Perimeter Security System Tests: Adjust sensitivity to value as low as possible, consistent with reliable detection.
- g. Long-Range PIR System Tests: Adjust sensitivity and hold time between activity duration to value as low as possible, consistent with reliable detection.
5. Report of Tests and Inspections: Prepare a written record of tests, inspections, and detailed test results in the form of a test log.
6. Tag all equipment, stations, and other components at which tests have been satisfactorily completed.
- G. Demonstration
  1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain perimeter security.
- H. Adjusting
  1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other than normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.

END OF SECTION 28 16 11 00

## SECTION 28 16 11 00a - INTRUSION DETECTION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for intrusion detection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes:
  - a. Intrusion detection with communication links to perform monitoring, alarm, and control functions.
2. Integration of other electronic and electrical systems and equipment.

#### C. Definitions

1. CCTV: Closed-circuit television.
2. PIR: Passive infrared.
3. RFI: Radio-frequency interference.
4. UPS: Uninterruptible power supply.
5. Control Unit: System component that monitors inputs and controls outputs through various circuits.
6. Master Control Unit: System component that accepts inputs from other control units and may also perform control-unit functions. The unit has limited capacity for the number of protected zones and is installed at an unattended location or at a location where it is not the attendant's primary function to monitor the security system.
7. Monitoring Station: Facility that receives signals and has personnel in attendance at all times to respond to signals. A central station is a monitoring station that is listed.
8. Protected Zone: A protected premises or an area within a protected premises that is provided with means to prevent an unwanted event.
9. Standard Intruder: A person who weighs **100 lb (45 kg)** or less and whose height is **60 inches (1525 mm)** or less; dressed in a long-sleeved shirt, slacks, and shoes unless environmental conditions at the site require protective clothing.
10. Standard-Intruder Movement: Any movement, such as walking, running, crawling, rolling, or jumping, of a "standard intruder" in a protected zone.
11. Systems Integration: The bringing together of components of several systems containing interacting components to achieve indicated functional operation of combined systems.
12. Zone: A defined area within a protected premises. It is a space or area for which an intrusion must be detected and uniquely identified. The sensor or group of sensors must then be assigned to perform the detection, and any interface equipment between sensors and communication must link to master control unit.

#### D. Action Submittals

1. Product Data: Components for sensing, detecting, systems integration, and control, including dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Show Drawings: Detail assemblies of standard components that are custom assembled for specific application on the Project.
  - a. Functional Block Diagram: Show single-line interconnections between components including interconnections between components specified in this Section and those furnished under other Sections. Indicate methods used to achieve systems integration. Indicate control, signal, and data communication paths and identify programmable logic controllers **OR** networks, **as directed** and control interface devices and media to be used. Describe characteristics of network and other data communication lines.



- 1) Indicate methods used to achieve systems integration.
- 2) Indicate control, signal, and data communication paths and identify PLCs, networks, control interface devices, and media to be used.
- 3) Describe characteristics of network and other data communication lines.
- 4) Describe methods used to protect against power outages and transient voltages including types and ratings of isolation and surge suppression devices used in data, communication, signal, control, and ac and dc power circuits.
- b. Raceway Riser Diagrams: Detail raceway runs required for intrusion detection and for systems integration. Include designation of devices connected by raceway, raceway type and size, and type and size of wire and cable fill for each raceway run.
- c. UPS: Sizing calculations.
- d. Site and Floor Plans: Indicate final outlet and device locations, routing of raceways, and cables inside and outside the building. Include room layout for master control-unit console, terminal cabinet, racks, and UPS.
- e. Master Control-Unit Console Layout: Show required artwork and device identification.
- f. Device Address List: Coordinate with final system programming.
- g. System Wiring Diagrams: Include system diagrams unique to Project. Show connections for all devices, components, and auxiliary equipment. Include diagrams for equipment and for system with all terminals and interconnections identified.
- h. Details of surge-protection devices and their installation.
- i. Sensor detection patterns and adjustment ranges.
3. Equipment and System Operation Description: Include method of operation and supervision of each component and each type of circuit. Show sequence of operations for manually and automatically initiated system or equipment inputs. Description must cover this specific Project; manufacturer's standard descriptions for generic systems are unacceptable.
4. Samples for Initial Selection: For units with factory-applied color finishes.
5. Samples for Verification: For each type of exposed finish required.

#### E. Information Submittals

1. Qualification Data: For Installer **OR** intrusion detection systems integrator **OR** testing agency, **as directed**.
2. Field quality-control reports.
3. Warranty: Sample of special warranty.
4. Other Information Submittals:
  - a. Test Plan and Schedule: Test plan defining all tests required to ensure that system meets technical, operational, and performance specifications within 60 days of date of Contract award.
  - b. Examination reports documenting inspections of substrates, areas, and conditions.
  - c. Anchor inspection reports documenting inspections of built-in and cast-in anchors.

#### F. Closeout Submittals

1. Operation and Maintenance Data: For intrusion detection system to include in emergency, operation, and maintenance manuals," include the following:
  - a. Data for each type of product, including features and operating sequences, both automatic and manual.
  - b. Master control-unit hardware and software data.

#### G. Quality Assurance

1. Installer Qualifications:
  - a. An employer of workers, at least one of whom is a technician certified by the National Burglar & Fire Alarm Association **OR** possess the standards and experience for certification, **as directed**.
  - b. Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

2. Intrusion Detection Systems Integrator Qualifications: An experienced intrusion detection equipment supplier and Installer who has completed systems integration work for installations similar in material, design, and extent to that indicated for this Project, whose work has resulted in construction with a record of successful in-service performance.
3. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the testing indicated, that is a member company of the National Burglar & Fire Alarm Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to Owner's insurance underwriter.
  - a. Testing Agency's Field Supervisor: Person currently certified as an advanced alarm technician by the National Burglar & Fire Alarm Association **OR** possess the standards and experience for certification, **as directed**, to supervise on-site testing specified in Part 3.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
5. Control Units, Devices, and Communications with Monitoring Station: Listed and labeled by a qualified testing agency for compliance with SIA CP-01.
6. FM Global Compliance: FMG-Approved and -labeled intrusion detection devices and equipment.
7. Comply with NFPA 70.

H. Project Conditions

1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
  - a. Altitude: Sea level to **4000 feet (1220 m)**.
  - b. Master Control Unit: Rated for continuous operation in an ambient of **60 to 85 deg F (16 to 29 deg C)** and a relative humidity of 20 to 80 percent, noncondensing.
  - c. Interior, Controlled Environment: System components, except master station control unit, installed in air-conditioned **OR** temperature-controlled, **as directed**, interior environments shall be rated for continuous operation in ambients of **36 to 122 deg F (2 to 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
  - d. Interior, Uncontrolled Environment: System components installed in non-air-conditioned **OR** non-temperature-controlled, **as directed**, interior environments shall be rated for continuous operation in ambients of **0 to 122 deg F (minus 18 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
  - e. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambients of **minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, condensing. Comply with UL 294 and UL 639 for outdoor-use equipment. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to **85 mph (137 km/h)** and snow cover up to **24 inches (610 mm)** thick.
  - f. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings shall be rated, listed, and installed according to NFPA 70.

I. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer and Installer agree to repair or replace components of intrusion detection devices and equipment that fail in materials or workmanship within specified warranty period.
2. Warranty Period: Two years from date of Final Completion.

1.2 PRODUCTS

A. Functional Description Of System

1. Description: Hard-wired **OR** Multiplexed, modular, microprocessor-based controls, intrusion sensors and detection devices, and communication links to perform monitoring, alarm, and control functions.



2. Supervision: System components shall be continuously monitored for normal, alarm, supervisory, and trouble conditions. Indicate deviations from normal conditions at any location in system. Indication includes identification of device or circuit in which deviation has occurred and whether deviation is an alarm or malfunction.
  - a. Alarm Signal: Display at master station control unit and actuate audible and visual alarm devices.
  - b. Trouble Condition Signal: Distinct from other signals, indicating that system is not fully functional. Trouble signal shall indicate system problems such as battery failure, open or shorted transmission line conductors, or controller failure.
  - c. Supervisory Condition Signal: Distinct from other signals, indicating an abnormal condition as specified for the particular device or controller.
3. System Control: Master station control unit shall directly monitor intrusion detection units and connecting wiring.  
**OR**  
 System Control: Master station control unit shall directly monitor intrusion detection devices, perimeter detection units **OR** controllers associated with perimeter detection units, **as directed**, and connecting wiring in a multiplexed distributed control system or as part of a network.
4. System shall automatically reboot program without error or loss of status or alarm data after any system disturbance.
5. Operator Commands:
  - a. Help with System Operation: Display all commands available to operator. Help command, followed by a specific command, shall produce a short explanation of the purpose, use, and system reaction to that command.
  - b. Acknowledge Alarm: To indicate that alarm message has been observed by operator.
  - c. Place Protected Zone in Access: Disable all intrusion-alarm circuits of a specific protected zone. Tamper circuits may not be disabled by operator.
  - d. Place Protected Zone in Secure: Activate all intrusion-alarm circuits of a protected zone.
  - e. Protected Zone Test: Initiate operational test of a specific protected zone.
  - f. System Test: Initiate system-wide operational test.
  - g. Print Reports.
6. Timed Control at Master station control unit: Allow automatically timed "secure" and "access" functions of selected protected zones.
7. Automatic Control of Related Systems: Alarm or supervisory signals from certain intrusion detection devices control the following functions in related systems:
  - a. Switch selected lights.
  - b. Shift elevator control to a different mode.
  - c. Open a signal path between certain intercommunication stations.
  - d. Shift sound system to "listening mode" and open a signal path to certain system speakers.
  - e. Switch signal to selected monitor from closed-circuit television camera in vicinity of sensor signaling an alarm.
8. Printed Record of Events: Print a record of alarm, supervisory, and trouble events on system printer. Sort and report by protected zone, device, and function. When master station control unit receives a signal, print a report of alarm, supervisory, or trouble condition. Report type of signal (alarm, supervisory, or trouble), protected zone description, date, and time of occurrence. Differentiate alarm signals from other indications. When system is reset, report reset event with the same information concerning device, location, date, and time. Commands shall initiate the reporting of a list of current alarm, supervisory, and trouble conditions in system or a log of past events.
9. Response Time: Two seconds between actuation of any alarm and its indication at master station control unit.
10. Circuit Supervision: Supervise all signal and data transmission lines, links with other systems, and sensors from master station control unit. Indicate circuit and detection device faults with both protected zone and trouble signals, sound a distinctive audible tone, and illuminate an LED. Maximum permissible elapsed time between occurrence of a trouble condition and indication at



- master station control unit is 20 seconds. Initiate an alarm in response to opening, closing, shorting, or grounding of a signal or data transmission line.
11. Programmed Secure-Access Control: System shall be programmable to automatically change status of various combinations of protected zones between secure and access conditions at scheduled times. Status changes may be preset for repetitive, daily, and weekly; specially scheduled operations may be preset up to a year in advance. Manual secure-access control stations shall override programmed settings.
  12. Manual Secure-Access Control: Coded entries at manual stations shall change status of associated protected zone between secure and access conditions.
- B. System Component Requirements
1. Compatibility: Detection devices and their communication features, connecting wiring, and master station control unit shall be selected and configured with accessories for full compatibility with existing equipment:
  2. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor entry connection to components.
    - a. Minimum Protection for Power Lines 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
    - b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Lines: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
  3. Intrusion Detection Units: Listed and labeled by a qualified testing agency for compliance with UL 639.
  4. Interference Protection: Components shall be unaffected by radiated RFI and electrical induction of 15 V/m over a frequency range of 10 to 10,000 MHz and conducted interference signals up to 0.25-V RMS injected into power supply lines at 10 to 10,000 MHz.
  5. Tamper Protection: Tamper switches on detection devices, controllers, annunciators, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled and when entering conductors are cut or disconnected. Central-station control-unit alarm display shall identify tamper alarms and indicate locations.
  6. Self-Testing Devices: Automatically test themselves periodically, but not less than once per hour, to verify normal device functioning and alarm initiation capability. Devices transmit test failure to master station control unit.
  7. Antimasking Devices: Automatically check operation continuously or at intervals of a minute or less, and use signal-processing logic to detect blocking, masking, jamming, tampering, or other operational dysfunction. Devices transmit detection of operational dysfunction to master station control unit as an alarm signal.
  8. Addressable Devices: Transmitter and receivers shall communicate unique device identification and status reports to master station control unit.
  9. Remote-Controlled Devices: Individually and remotely adjustable for sensitivity and individually monitored at master station control unit for calibration, sensitivity, and alarm condition.
- C. Enclosures
1. Interior Sensors: Enclosures that protect against dust, falling dirt, and dripping noncorrosive liquids.
  2. Interior Electronics: NEMA 250, Type 12.
  3. Exterior Electronics: NEMA 250, Type 4X fiberglass **OR** stainless steel, **as directed**.
  4. Corrosion Resistant: NEMA 250, Type 4X PVC **OR** stainless steel, **as directed**.
  5. Screw Covers: Where enclosures are accessible to inmates, secure with security fasteners of type appropriate for enclosure.
- D. Secure And Access Devices





1. Keypad and Display Module: Arranged for entering and executing commands for system-status changes and for displaying system-status and command-related data.
2. Key-Operated Switch: Change protected zone between secure and access conditions.

E. Door And Window Switches

1. Description: Balanced-magnetic switch, complying with UL 634, installed on frame with integral overcurrent device to limit current to 80 percent of switch capacity. Bias magnet and minimum of two **OR** three, **as directed**, encapsulated reed switches shall resist compromise from introduction of foreign magnetic fields.
2. Flush-Mounted Switches: Unobtrusive and flush with surface of door and window frame.
3. Overhead Door Switch: Balanced-magnetic type, listed for outdoor locations, and having door-mounting magnet and floor-mounting switch unit.
4. Remote Test: Simulate movement of actuating magnet from master station control unit.

F. PIR Sensors

1. Listed and labeled by a qualified testing agency for compliance with SIA PIR-01.
2. Description: Sensors detect intrusion by monitoring infrared wavelengths emitted from a human body within their protected zone and by being insensitive to general thermal variations.
  - a. Wall-Mounting Unit Maximum Detection Range: 125 percent of indicated distance for individual units and not less than **50 feet (15 m)**. Provide adjustable coverage pattern as indicated.
  - b. Ceiling-Mounting Unit Spot-Detection Pattern: Full 360-degree conical.
  - c. Ceiling-Mounting Unit Pattern Size: **84-inch (2135-mm)** diameter at floor level for units mounted **96 inches (2440 mm)** above floor; **18-foot (5.5-m)** diameter at floor level for units mounted **25 feet (7.6 m)** above floor.
3. Device Performance:
  - a. Sensitivity: Adjustable pattern coverage to detect a change in temperature of **2 deg F (1deg C)** or less, and standard-intruder movement within sensor's detection patterns at any speed between **0.3 to 7.5 fps (0.09 to 2.3 m/s)** across 2 adjacent segments of detector's field of view.
  - b. Test Indicator: LED test indicator that is not visible during normal operation. When visible, indicator shall light when sensor detects an intruder. Locate test enabling switch under sensor housing cover.
  - c. Remote Test: When initiated by master station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

G. Microwave Intrusion Detectors (Interior)

1. Device Performance: Microwave transmitter establishes an electromagnetic field in an adjustable detection pattern and detects intrusion by monitoring changes in that pattern.
  - a. Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between **0.3 to 7.5 fps (0.09 to 2.3 m/s)**. Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
  - b. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test-enabling switch under sensor housing cover.
  - c. Remote Test: When initiated by master station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

H. Acoustic-Type, Glass-Break Sensors

1. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
2. Device Performance: Detect unique, airborne acoustic energy spectrum caused by breaking glass.

- a. Sensor Element: Microprocessor-based, digital device to detect breakage of plate, laminate, tempered, and wired glass while rejecting common causes of false alarms. Detection pattern shall be at least a **20-foot (6-m)** range.
  - b. Hookup Cable: Factory installed, not less than **72 inches (1830 mm)**.
  - c. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor controller or at master station control unit.
  - d. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
  - e. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.
- I. Piezoelectric-Type, Glass-Break Sensors
- 1. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
  - 2. Device Performance: Detect unique, high-frequency vibrations caused by breaking glass.
    - a. Sensor Element: Piezoelectric crystals in a housing designed to mount directly to glass surface with adhesive provided by element manufacturer. Circular detection pattern, with at least a **60-inch (1525-mm)** radius on a continuous glass pane. Sensor element shall not be larger than **4 sq. in. (25.80 sq. cm)**.
    - b. Hookup Cable: Factory installed, not less than **72 inches (1830 mm)**.
    - c. Activation Indicator: LED on sensor housing that lights when responding to vibrations, remaining on until manually reset at sensor controller or at master station control unit.
    - d. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
    - e. Glass-Break Simulator: A device to induce frequencies into protected glass pane that simulate breaking glass without causing damage to glass.
- J. Vibration Sensors
- 1. Listed and labeled by a qualified testing agency for compliance with SIA GB-01.
  - 2. Description: A sensor controller and piezoelectric crystal sensor elements that are designed to be rigidly mounted to structure being protected.
  - 3. Device Performance: Detects high-frequency vibrations generated by use of such tools as oxyacetylene torches, oxygen lances, high-speed drills and saws, and explosives that penetrate a structure while not responding to any other mechanical vibration.
    - a. Circular detection pattern, with at least a **72-inch (1830-mm)** radius on protected structure.
    - b. Hookup Cable: Factory installed, not less than **72 inches (1830 mm)**.
    - c. Controller: Integral with sensor housing or in a separate assembly, locally adjustable by control under housing cover.
    - d. Glass-Break Simulator: A device to induce frequencies to protected glass pane that simulate breaking glass without causing damage to glass.
- K. Photoelectric Sensors
- 1. Device Performance: Detect an interruption of a pulsed, infrared, light beam that links transmitter and receiver.
    - a. Sensitivity: Detect standard-intruder movement within sensor's detection patterns at any speed of less than **7.5 fps (2.3 m/s)** though the beam. Allow installation of multiple sensors within same protected zone that will not interfere with each other.
    - b. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.
    - c. Remote Test: When initiated by master station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.
- L. Microwave-PIR Dual-Technology Motion Sensors



1. Description: Single unit combining a sensor that detects changes in microwave signals and a PIR sensor that detects changes in ambient level of infrared emissions caused by standard-intruder movement within detection pattern.
2. Device Performance: An alarm is transmitted when either sensor detects a standard intruder within a period of three to eight seconds from when the other sensor detects a standard intruder.
  - a. Minimum Detection Pattern: A room 20 by 30 feet (6 by 9 m).
  - b. PIR Sensor Sensitivity: Adjustable pattern coverage to detect a change in temperature of 2 deg F (1 deg C) or less, and standard-intruder movement within sensor's detection patterns at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s) across 2 adjacent segments of detector's field of view.
  - c. Microwave Sensor Sensitivity: Adjustable, able to detect standard-intruder movement within sensor's detection pattern at any speed between 0.3 to 7.5 fps (0.09 to 2.3 m/s). Sensor sensitivity adjustments shall be accessible only when sensor housing is removed, and sensors shall comply with 47 CFR 15.
  - d. Activation Indicator: LED indicator shall not be visible during normal operation. Indicator shall light when sensor detects a standard intruder. Locate test enabling switch under sensor housing cover.
  - e. Remote Test: When initiated by master station control unit, start a test sequence for each detector element that simulates standard-intruder movement within sensor's detection patterns, causing an alarm.

#### M. Duress-Alarm Switches

1. Description: A switch with a shroud over the activating lever that allows an individual to covertly send a duress signal to master station control unit, with no visible or audible indication when activated. Switch shall lock in activated position until reset with a key.
  - a. Minimum Switch Rating: 50,000 operations.
  - b. Foot Rail: Foot activated, floor mounting.
  - c. Push Button: Finger activated, suitable for mounting on horizontal or vertical surface.

#### N. Video Motion Sensor (Interior)

1. Device Performance: Detect changes in video signal within a user-defined protected zone. Video inputs shall be composite video as defined in EIA 170. Provide an alarm output for each video input.
  - a. Detect movement within protected zone of standard intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of 2. Reject all other changes in video signal.
  - b. Modular design that allows for expansion or modification of number of inputs.
  - c. Controls:
    - 1) Number of detection zones.
    - 2) Size of detection zones.
    - 3) Sensitivity of detection of each protected zone.
  - d. Mounting: Standard 19-inch (480-mm) rack as described in EIA 310.

#### O. Master Control Units

1. Description: Supervise sensors and detection subsystems and their connecting communication links, status control (secure or access) of sensors and detector subsystems, activation of alarms and supervisory and trouble signals, and other indicated functions.
  - a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
  - b. Include a real-time clock for time annotation of events on the event recorder and printer.
  - c. Addressable initiation devices that communicate device identity and status.
  - d. Control circuits for operation of mechanical equipment in response to an alarm.
2. Construction: Freestanding equipment rack **OR** Desk-mounted console, **as directed** modular, with separate and independent alarm and supervisory system modules. Alarm-initiating protected

- zone boards shall be plug-in cards. Arrangements that require removal of field wiring for module replacement are unacceptable.
3. Comply with UL 609 **OR** UL 1023 **OR** UL 1076, **as directed**.
  4. Console Controls and Displays: Arranged for interface between human operator at master control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
    - a. Annunciator and Display: LCD, one **OR** two **OR** three line(s), as directed of 40 **OR** 80 characters, as directed, minimum.
    - b. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
    - c. Control-Unit Network: Automatic communication of alarm, status changes, commands, and other communications required for system operation. Communication shall return to normal after partial or total network interruption such as power loss or transient event. Total or partial signaling network failures shall identify the failure and record the failure at the annunciator display and at the system printer.
    - d. Field Device Network: Communicate between the control unit and field devices of the system. Communications shall consist of alarm, network status, and status and control of field-mounted processors. Each field-mounted device shall be interrogated during each interrogation cycle.
    - e. Operator Controls: Manual switches and push-to-test buttons that do not require a key to operate. Prevent resetting of alarm, supervisory, or trouble signals while alarm or trouble condition persists. Include the following:
      - 1) Acknowledge alarm.
      - 2) Silence alarm.
      - 3) System reset.
      - 4) LED test.
    - f. Timing Unit: Solid state, programmable, 365 days.
    - g. Confirmation: Relays, contactors, and other control devices shall have auxiliary contacts that provide confirmation signals to system for their on or off status. Software shall interpret such signals, display equipment status, and initiate failure signals.
    - h. Alarm Indication: Audible signal sounds and a plain-language identification **OR** LED **OR** LCD **OR** cathode ray-tube display at master control unit identifying the protected zone **OR** addressable detector, **as directed** originating the alarm. Annunciator panel displays a common alarm light and sounds an audible tone.
    - i. Alarm activation sounds a bell or siren or strobe **OR** bell or siren and strobe, **as directed**.
  5. Protected Zones: Quantity of alarm and supervisory zones as indicated, with capacity for expanding number of protected zones by a minimum of 25 percent.
  6. Power Supply Circuits: Master station control units shall provide power for remote power-consuming detection devices. Circuit capacity shall be adequate for at least a 25 percent increase in load.
  7. UPS: Comply with Division 26 Section "Static Uninterruptible Power Supply". UPS shall be sized to provide a minimum of six hours of central-station control-unit operation.
  8. Cabinet: Lockable, steel enclosure arranged so operations required for testing, normal operation, and maintenance are performed from front of enclosure. If more than a single cabinet is required to form a complete control unit, provide exactly matching modular enclosures. Accommodate all components and allow ample gutter space for field wiring. Identify each enclosure by an engraved, laminated, phenolic-resin nameplate. Lettering on enclosure nameplate shall not be less than **1 inch (25 mm)** high. Identify, with permanent labels, individual components and modules within cabinets.
  9. Transmission to Monitoring Station: A communications device to automatically transmit alarm, supervisory, and trouble signals to the monitoring station, operating over a standard voice grade telephone leased line. Comply with UL 1635.
  10. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print



system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

P. Audible And Visual Alarm Devices

1. Bell: 10 inches (254 mm) in diameter, rated to produce a minimum sound output of 84 dB at 10 feet (3 m) from master control unit.
  - a. Enclosure: Weather-resistant steel box equipped with tamper switches on cover and on back of box.
2. Klaxon Weatherproof Motor-Driven Hooter: UL listed, rated to produce a minimum sound output of 120 dB at 3 feet (1 m), plus or minus 3 dB, at a frequency of 470 Hz. Rated for intermittent use: two minutes on and five minutes off.
  - a. Designed for use in industrial areas and in high-noise, severe-weather marine environments.
3. Siren: 30-W speaker with siren driver, rated to produce a minimum sound output of 103 dB at 10 feet (3 m) from master control unit.
  - a. Enclosure: Weather-resistant steel box with tamper switches on cover and on back of box.
4. Strobe: Xenon light complying with UL 1638, with a clear polycarbonate lens.
  - a. Light Output: 115 cd, minimum.
  - b. Flash Rate: 60 per minute.

Q. Security Fasteners

1. Operable only by tools produced for use on specific type of fastener by fastener manufacturer or other licensed fabricator. Drive system type, head style, material, and protective coating as required for assembly, installation, and strength.
2. Drive System Types: Pinned Torx-Plus **OR** pinned Torx **OR** pinned hex (Allen), **as directed**.
3. Socket Flat Countersunk Head Fasteners:
  - a. Heat-treated alloy steel, **ASTM F 835 (ASTM F 835M)**.
  - b. Stainless steel, **ASTM F 879 (ASTM F 879M)**, Group 1 CW.
4. Socket Button Head Fasteners:
  - a. Heat-treated alloy steel, **ASTM F 835 (ASTM F 835M)**.
  - b. Stainless steel, **ASTM F 879 (ASTM F 879M)**, Group 1 CW.
5. Socket Head Cap Fasteners:
  - a. Heat-treated alloy steel, **ASTM A 574 (ASTM A 574M)**.
  - b. Stainless steel, **ASTM F 837 (ASTM F 837M)**, Group 1 CW.
6. Protective Coatings for Heat-Treated Alloy Steel:
  - a. Zinc chromate, ASTM F 1135, Grade 3 or Grade 4, for exterior applications and interior applications where indicated.
  - b. Zinc phosphate with oil, ASTM F 1137, Grade I, or black oxide unless otherwise indicated.

### 1.3 EXECUTION

A. Examination

1. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of intrusion detection.
2. Examine roughing-in for embedded and built-in anchors to verify actual locations of intrusion detection connections before intrusion detection installation.
3. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of intrusion detection.
4. Inspect built-in and cast-in anchor installations, before installing intrusion detection, to verify that anchor installations comply with requirements. Prepare inspection reports.
  - a. Remove and replace anchors where inspections indicate that they do not comply with requirements. Reinspect after repairs or replacements are made.



- b. Perform additional inspections to determine compliance of replaced or additional anchor installations. Prepare inspection reports.
5. For material whose orientation is critical for its performance as a ballistic barrier, verify installation orientation.
6. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. System Integration
  1. Electronic door hardware.
  2. Elevators.
  3. Network lighting controls.
  4. Intercommunications and program systems.
  5. Public address and mass notification systems.
  6. Access control.
  7. Fire-alarm system.
  8. Perimeter security system.
  9. Video surveillance.
- C. System Installation
  1. Comply with UL 681 and NFPA 731.
  2. Equipment Mounting: Install master control unit on finished floor with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
    - a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
  3. Install wall-mounted equipment, with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
    - a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
  4. Connecting to Existing Equipment: Verify that existing perimeter security system is operational before making changes or connections.
    - a. Connect new equipment to existing control panel in existing part of the building.
    - b. Connect new equipment to existing monitoring equipment at the Supervising Station.
    - c. Expand, modify, and supplement existing control **OR** monitoring equipment, **as directed** as necessary to extend existing control **OR** monitoring functions, **as directed** to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
  5. Security Fasteners: Where accessible to inmates, install intrusion detection components using security fasteners with head style appropriate for fabrication requirements, strength, and finish of adjacent materials except that a maximum of two different sets of tools shall be required to operate security fasteners for Project. Provide stainless-steel security fasteners in stainless-steel materials.
- D. Wiring Installation
  1. Wiring Method: Install wiring in metal raceways according to Division 26 Section "Raceway And Boxes For Electrical Systems". Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be **1/2 inch (13 mm)**. Control and data transmission wiring shall not share conduit with other building wiring systems.
  2. Wiring Method: Install wiring in raceways except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be **1/2 inch (13 mm)**. Control and data transmission wiring shall not share conduit with other building wiring systems.
  3. Wiring Method: Cable, concealed in accessible ceilings, walls, and floors when possible.
  4. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according



to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

5. Wires and Cables:

- a. Conductors: Size as recommended in writing by system manufacturer, unless otherwise indicated.
- b. 120-V Power Wiring: Install according to Division 26 Section "Low-voltage Electrical Power Conductors And Cables", unless otherwise indicated.
- c. Control and Signal Transmission Conductors: Install unshielded, twisted-pair cable, unless otherwise indicated or if manufacturer recommends shielded cable, according to Division 28 Section "Conductors And Cables For Electronic Safety And Security".
- d. Data and Television Signal Transmission Cables: Install according to Division 28 Section "Conductors And Cables For Electronic Safety And Security".

6. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

7. Install power supplies and other auxiliary components for detection devices at controllers, unless otherwise indicated or required by manufacturer. Do not install such items near devices they serve.

8. Identify components with engraved, laminated-plastic or metal nameplate for master station control unit and each terminal cabinet, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section "Identification For Electrical Systems".

E. Identification

1. Identify system components, wiring, cabling, and terminals. Comply with identification requirements as specified in Division 26 Section "Identification For Electrical Systems".
2. Install instructions frame in a location visible from master control unit.

F. Grounding

1. Ground the master control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to master control unit.
2. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
3. Signal Ground Terminal: Locate at main equipment rack or cabinet. Isolate from power system and equipment grounding. Provide 5-ohm ground. Measure, record, and report ground resistance.
4. Install grounding electrodes of type, size, location, and quantity indicated. Comply with installation requirements in Division 26 Section "Grounding And Bonding For Electrical Systems".

G. Field Quality Control

1. Pretesting: After installation, align, adjust, and balance system and perform complete pretesting to determine compliance of system with requirements in the Contract Documents. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new ones and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
  - a. Report of Pretesting: After pretesting is complete, provide a letter certifying that installation is complete and fully operable; include names and titles of witnesses to preliminary tests.
2. Testing Agency: Engage a qualified testing and inspecting agency to perform tests and inspections.
3. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect test, and adjust components, assemblies, and equipment installations connections.
4. Perform tests and inspections.
  - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
5. Test and Inspections: Comply with provisions in NFPA 731, Ch.9, "Testing and Inspections."

- a. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
  - b. Test Methods: Intrusion detection systems and other systems and equipment that are associated with detection and accessory equipment shall be tested according to Table "Test Methods" and Table "Test Methods of Initiating Devices."
6. Documentation: Comply with provisions in NFPA 731, Ch. 4, "Documentation."
7. Tag all equipment, stations, and other components for which tests have been satisfactorily completed.
- 8.
- H. Adjusting
  1. Occupancy Adjustments: When requested within 12 months of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to three visits to Project during other than normal occupancy hours for this purpose. Visits for this purpose shall be in addition to any required by warranty.
- I. Demonstration
  1. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain intrusion detection system. Comply with documentation provisions in NFPA 731, Ch.4, "Documentation and User Training."

END OF SECTION 28 16 11 00a



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## SECTION 28 16 11 00b - SECURITY ACCESS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for security access. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Security access central-control station.
  - b. One or more security access networked workstations.
  - c. Security access operating system and application software.
  - d. Security access controllers connected to high-speed electronic-data transmission network.

#### C. Definitions

1. CCTV: Closed-circuit television.
2. CPU: Central processing unit.
3. Credential: Data assigned to an entity and used to identify that entity.
4. dpi: Dots per inch.
5. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
6. GFI: Ground fault interrupter.
7. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.
8. I/O: Input/Output.
9. LAN: Local area network.
10. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.
11. PC: Personal computer. Applies to the central station, workstations, and file servers.
12. PCI Bus: Peripheral Component Interconnect. A peripheral bus providing a high-speed data path between the CPU and the peripheral devices such as a monitor, disk drive, or network.
13. PDF: Portable Document Format. The file format used by the Acrobat document-exchange-system software from Adobe.
14. RAS: Remote access services.
15. RF: Radio frequency.
16. ROM: Read-only memory. ROM data are maintained through losses of power.
17. TCP/IP: Transport control protocol/Internet protocol incorporated into Microsoft Windows.
18. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
19. UPS: Uninterruptible power supply.
20. USB: Universal serial bus.
21. WAN: Wide area network.
22. WAV: The digital audio format used in Microsoft Windows.
23. WMP: Windows media player.
24. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.



25. Windows: Operating system by Microsoft Corporation.
26. Workstation: A PC with software that is configured for specific, limited security-system functions.
27. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

D. Submittals

1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
  - a. Diagrams for cable management system.
  - b. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 1.2 and 1.3.
  - c. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
    - 1) Workstation outlets, jacks, and jack assemblies.
    - 2) Patch cords.
    - 3) Patch panels.
  - d. Cable Administration Drawings: As specified in Part 1.3 "Identification" Article.
  - e. Battery and charger calculations for Central Station, workstations, and Controllers.
3. Samples: For workstation outlets, jacks, jack assemblies, and faceplates. For each exposed product and for each color and texture specified.
4. Other Action Submittals:
  - a. Project planning documents as specified in Part 1.3.
5. Field quality-control test reports.
6. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. Include the following:
  - a. Microsoft Windows software documentation.
  - b. PC installation and operating documentation, manuals, and software for the PC and all installed peripherals. Software shall include system restore, emergency boot diskettes, and drivers for all installed hardware. Provide separately for each PC.
  - c. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on CD-ROM of the hard-copy submittal.
  - d. System installation and setup guides, with data forms to plan and record options and setup decisions.

E. Quality Assurance

1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
  - a. Cable installer must have on staff a registered communication distribution designer certified by Building Industry Consulting Service International.
2. Source Limitations: Obtain Central Station, workstations, Controllers, Identifier readers, and all software through one source from a single manufacturer.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70 by a qualified testing agency, and marked for intended use.
4. Comply with NFPA 70, "National Electrical Code."
5. Comply with SIA DC-01 and SIA DC-03 and SIA DC-07, **as directed**.

F. Delivery, Storage, And Handling

1. Central Station, Workstations, and Controllers:
  - a. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50 and 85 deg F (10 and 30 deg C), and not more than 80 percent relative humidity, noncondensing.
  - b. Open each container; verify contents against packing list, and file copy of packing list, complete with container identification for inclusion in operation and maintenance data.

- c. Mark packing list with designations that have been assigned to materials and equipment for recording in the system labeling schedules that are generated by cable and asset management system specified in Part 2.
- d. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

G. Project Conditions

- 1. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
  - a. Control Station: Rated for continuous operation in ambient conditions of **60 to 85 deg F (16 to 30 deg C)** and a relative humidity of 20 to 80 percent, noncondensing.
  - b. Indoor, Controlled Environment: NEMA 250, Type 1 enclosure. System components, except central-station control unit, installed in air-conditioned **OR** temperature-controlled, **as directed**, indoor environments shall be rated for continuous operation in ambient conditions of **36 to 122 deg F (2 to 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
  - c. Indoor, Uncontrolled Environment: NEMA 250, Type 3R **OR** 4 **OR** 12 **OR** 12K, **as directed**, enclosures. System components installed in non-air-conditioned **OR** non-temperature-controlled, **as directed**, interior environments shall be rated for continuous operation in ambient conditions of **0 to 122 deg F (minus 18 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing.
  - d. Outdoor Environment: NEMA 250, Type 3 **OR** 3R **OR** 3S **OR** 4 **OR** 4X, **as directed**, enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of **minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to **85 mph (137 km/h)** and snow cover up to **24 inches (610 mm)** thick.
  - e. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.
  - f. Corrosive Environment: For system components subjected to corrosive fumes, vapors, and wind-driven salt spray in coastal zones, provide NEMA 250, Type 4X **OR** 6P, **as directed**, enclosures.

1.2 PRODUCTS

A. Description

- 1. Security Access System: PC-based central station, one or more networked PC-based workstations, and field-installed controllers, connected by a high-speed electronic-data transmission network.
- 2. System Software: Based on 32-bit, central-station, workstation operating system, server operating system, and application software. Software shall have the following capabilities:
  - a. Multiuser and multitasking to allow for independent activities and monitoring to occur simultaneously at different workstations.
  - b. Graphical user interface to show pull-down menus and a menu-tree format that complies with interface guidelines of Microsoft Windows.
  - c. System license for the entire system including capability for future additions that are within the indicated system size limits specified in this Section.
  - d. Open-architecture system that allows importing and exporting of data and interfacing with other systems that are compatible with Microsoft Windows.
  - e. Password-protected operator login and access.
  - f. Open-database-connectivity compliant.
- 3. Network connecting the central station and workstations shall be a LAN **OR** WAN, **as directed**, using Microsoft Windows-based TCP/IP with a capacity of connecting up to 99 workstations.



System shall be portable across multiple communication platforms without changing system software.

4. Network(s) connecting PCs and controllers shall consist of one or more of the following:
  - a. Local area, IEEE 802.3 Fast Ethernet Gigabit-Ethernet **OR** 100 BASE-TX, **as directed**, star topology network based on TCP/IP.
  - b. Direct-connected, RS-232 cable from the COM port of the central station to the first controller, then RS-485 cable to interconnect the remaining controllers at that Location.
  - c. Dial-up and cable modem connection using a standard cable or dial-up telephone line.

B. Operation

1. Security access system shall use a single database for access-control and credential-creation functions.
2. Distributed Processing: A fully distributed processing system.
  - a. Access-control information, including time, date, valid codes, access levels, and similar data, shall be downloaded to controllers so each controller can make access-control decisions.
  - b. Intermediate controllers for access control are prohibited.
  - c. In the event that communications with the central controller are lost, controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the central station.
3. Number of Locations:
  - a. Support at least 32,000 separate Locations using a single PC with combinations of direct-connect, dial-up, or TCP/IP LAN connections to each Location.
  - b. Each Location shall have its own database and history in the central station.
  - c. Locations may be combined to share a common database.
4. Data Capacity:
  - a. 130 different card-reader formats.
  - b. 999 comments.
  - c. 48 graphic file types for importing maps.
5. Location Capacity:
  - a. 128 reader-controlled doors.
  - b. 50,000 total-access credentials.
  - c. 2048 supervised alarm inputs.
  - d. 2048 programmable outputs.
  - e. 32,000 custom action messages per Location to instruct operator on action required when alarm is received.
6. System Network Requirements:
  - a. System components shall be interconnected and shall provide automatic communication of status changes, commands, field-initiated interrupts, and other communications required for proper system operation.
  - b. Communication shall not require operator initiation or response and shall return to normal after partial- or total-network interruption such as power loss or transient upset.
  - c. System shall automatically annunciate communication failures to the operator and shall identify the communications link that has experienced a partial or total failure.
  - d. Communications controller may be used as an interface between the central-station display systems and the field device network. Communications controller shall provide functions required to attain the specified network communications performance.
7. Central station shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Central station shall control system networks to interconnect all system components, including workstations and field-installed controllers.
8. Field equipment shall include controllers, sensors, and controls.
  - a. Controllers shall serve as an interface between the central station and sensors and controls.
  - b. Data exchange between the central station and the controllers shall include down-line transmission of commands, software, and databases to controllers.

- c. The up-line data exchange from the controller to the central station shall include status data such as intrusion alarms, status reports, and entry-control records.
    - d. Controllers are classified as alarm-annunciation or entry-control type.
  9. System Response to Alarms:
    - a. Field device network shall provide a system end-to-end response time of one second(s) or less for every device connected to the system.
    - b. Alarms shall be annunciated at the central station within one second of the alarm occurring at a controller or at a device controlled by a local controller, and within 100 ms if the alarm occurs at the central station.
    - c. Alarm and status changes shall be displayed within 100 ms after receipt of data by the central station.
    - d. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within five seconds of alarm receipt at the security console.
    - e. This response time shall be maintained during system heavy load.
  10. False-Alarm Reduction: The design of the central station and controllers shall contain features to reduce false alarms. Equipment and software shall comply with SIA CP-01.
  11. Error Detection:
    - a. Use a cyclic code method to detect single- and double-bit errors, burst errors of eight bits or fewer, and at least 99 percent of all other multibit and burst errors between controllers and the central station.
    - b. Interactive or product error-detection codes alone will not be acceptable.
    - c. A message shall be in error if one bit is received incorrectly.
    - d. Retransmit messages with detected errors.
    - e. Allow for an operator-assigned two-digit decimal number to each communications link representing the number of retransmission attempts.
    - f. Central station shall print a communication failure alarm message when the number of consecutive retransmission attempts equals the assigned quantity.
    - g. Monitor the frequency of data transmission failure for display and logging.
  12. Data Line Supervision: System shall initiate an alarm in response to opening, closing, shorting, or grounding of data transmission lines.
  13. Door Hardware Interface:
    - a. Comply with requirements in Division 8 Sections for door hardware required to be monitored or controlled by the security access system.
    - b. Electrical characteristics of controllers shall match the signal and power requirements of door hardware.
- C. Application Software
  1. System Software: Based on 32-bit, Microsoft Windows central-station and workstation operating system and application software.
    - a. Multiuser multitasking shall allow independent activities and monitoring to occur simultaneously at different workstations.
    - b. Graphical user interface shall show pull-down menus and a menu-tree format.
    - c. Capability for future additions within the indicated system size limits.
    - d. Open architecture that allows importing and exporting of data and interfacing with other systems that are compatible with operating system.
    - e. Password-protected operator login and access.
  2. Peer Computer Control Software: Detect a failure of a central computer and cause the other central computer to assume control of all system functions without interruption of operation. Both central computers shall have drivers to support this mode of operation.
  3. Application Software: Interface between the alarm annunciation and entry-control controllers to monitor sensors and DTS links, operate displays, report alarms, generate reports, and help train system operators.
    - a. Reside at the central station, workstations, and controllers as required to perform specified functions.
    - b. Operate and manage peripheral devices.



- c. Manage files for disk I/O, including creating, deleting, and copying files; and automatically maintain a directory of all files, including size and location of each sequential and random-ordered record.
- d. Import custom icons into graphics to represent alarms and I/O devices.
- e. Globally link I/O so that any I/O can link to any other I/O within the same Location without requiring interaction with the host PC. This operation shall be at the controller.
- f. Globally code I/O links so that any access-granted event can link to any I/O with the same Location without requiring interaction with the host PC. This operation shall be at the controller.
- g. Messages from PC to controllers and controllers to controllers shall be on a polled network that utilizes check summing and acknowledgment of each message. Communication shall be automatically verified, buffered, and retransmitted if message is not acknowledged.
- h. Selectable poll frequency and message time-out settings shall handle bandwidth and latency issues for TCP/IP, RF, and other PC-to-controller communications methods by changing the polling frequency and the amount of time the system waits for a response.
- i. Automatic and encrypted backups for database and history backups shall be automatically stored at the central-control PC **OR** a selected workstation, **as directed**, and encrypted with a nine-character alphanumeric password that must be used to restore or read data contained in backup.
- j. Operator audit trail for recording and reporting all changes made to database and system software.
- k. Support network protocol and topology, TCP/IP, Novel Netware, Digital Pathworks, Banyan Vines, LAN/WAN, and RAS.
- 4. Workstation Software:
  - a. Password levels shall be individually customized at each workstation to allow or disallow operator access to program functions for each Location.
  - b. Workstation event filtering shall allow user to define events and alarms that will be displayed at each workstation. If an alarm is unacknowledged (not handled by another workstation) for a preset amount of time, the alarm will automatically appear on the filtered workstation.
- 5. Controller Software:
  - a. Controllers shall operate as autonomous, intelligent processing units.
    - 1) Controllers shall make decisions about access control, alarm monitoring, linking functions, and door-locking schedules for their operation, independent of other system components.
    - 2) Controllers shall be part of a fully distributed processing-control network.
    - 3) The portion of the database associated with a controller, and consisting of parameters, constraints, and the latest value or status of points connected to that controller, shall be maintained in the controller.
  - b. The following functions shall be fully implemented and operational within each controller:
    - 1) Monitoring inputs.
    - 2) Controlling outputs.
    - 3) Automatically reporting alarms to the central station.
    - 4) Reporting of sensor and output status to the central station on request.
    - 5) Maintaining real time, automatically updated by the central station at least once a day.
    - 6) Communicating with the central station.
    - 7) Executing controller resident programs.
    - 8) Diagnosing.
    - 9) Downloading and uploading data to and from the central station.
  - c. Controller Operations at a Location:
    - 1) Up to 64 controllers connected to TIA 485-A communications loop. Globally operating I/O linking and anti-passback functions between controllers within the same Location without central-station or workstation intervention. Linking and anti-

- passback shall remain fully functional within the same Location even when the central station or workstations are off-line.
- 2) In the event of communication failure between the central station and a Location, there shall be no degradation in operations at the controllers at that Location. Controllers at each Location shall be connected to a memory buffer with a capacity to store up to 10,000 events; there shall be no loss of transactions in system history files until the buffer overflows.
  - 3) Buffered events shall be handled in a first-in-first-out mode of operation.
- d. Individual Controller Operation:
- 1) Controllers shall transmit alarms, status changes, and other data to the central station when communications circuits are operable. If communications are not available, controllers shall function in a stand-alone mode; operational data, including the status and alarm data normally transmitted to the central station, shall be stored for later transmission to the central station. Storage capacity for the latest 1024 events shall be provided at each controller.
  - 2) Card-reader ports of a controller shall be custom configurable for at least 120 different card-reader or keypad formats. Multiple reader or keypad formats may be used simultaneously at different controllers or within the same controller.
  - 3) Controllers shall provide a response to card readers or keypad entries in less than 0.25 seconds, regardless of system size.
  - 4) Controllers that are reset, or powered up from a nonpowered state, shall automatically request a parameter download and reboot to their proper working state. This shall happen without any operator intervention.
  - 5) Initial Startup: When controllers are brought on-line, database parameters shall be automatically downloaded to them. After initial download is completed, only database changes shall be downloaded to each controller.
  - 6) On failure for any reason, controllers shall perform an orderly shutdown and force controller outputs to a predetermined failure-mode state, consistent with the failure modes shown and the associated control device.
  - 7) After power is restored, following a power failure, startup software shall initiate self-test diagnostic routines, after which controllers shall resume normal operation.
  - 8) After controller failure, if the database and application software are no longer resident, controllers shall not restart but shall remain in the failure mode until repaired. If database and application programs are resident, controllers shall immediately resume operation. If not, software shall be restored automatically from the central station.
- e. Communications Monitoring:
- 1) System shall monitor and report status of TIA 485-A communications loop of each Location.
  - 2) Communication status window shall display which controllers are currently communicating, a total count of missed polls since midnight, and which controller last missed a poll.
  - 3) Communication status window shall show the type of CPU, the type of I/O board, and the amount of RAM for each controller.
- f. Operating systems shall include a real-time clock function that maintains seconds, minutes, hours, day, date, and month. The real-time clock shall be automatically synchronized with the central station at least once a day to plus or minus 10 seconds. The time synchronization shall be automatic, without operator action and without requiring system shutdown.
6. PC-to-Controller Communications:
- a. Central-station or workstation communications shall use the following:
    - 1) Direct connection using serial ports of the PC.
    - 2) TCP/IP LAN interface cards.
    - 3) Dial-up or cable modems for connections to Locations.
  - b. Each serial port used for communications shall be individually configurable for "direct communications," "modem communications incoming and outgoing," or "modem





- communications incoming only," or as an ASCII output port. Serial ports shall have adjustable data transmission rates and shall be selectable under program control.
- c. Use multiport communications board if more than two serial ports are needed.
    - 1) Use a 4-, 8-, or 16-serial port configuration that is expandable to 32- or 64-serial ports.
    - 2) Connect the first board to an internal PCI bus adapter card.
  - d. Direct serial, TCP/IP, and dial-up, cable, or satellite communications shall be alike in the monitoring or control of the system except for the connection that must first be made to a dial-up or voice-over IP Location.
  - e. TCP/IP network interface card (NIV) shall have an option to set the poll-frequency and message-response time-out settings.
  - f. PC-to-controller and controller-to-controller communications (direct, dial-up, or TCP/IP) shall use a polled-communication protocol that checks sum and acknowledges each message. All communications in this subparagraph shall be verified and buffered, and retransmitted if not acknowledged.
7. Direct Serial or TCP/IP PC-to-Controller Communications:
- a. Communication software on the PC shall supervise the PC-to-controller communications link.
  - b. Loss of communications to any controller shall result in an alarm at all PCs running the communication software.
  - c. When communications are restored, all buffered events shall automatically upload to the PC, and any database changes shall be automatically sent to the controller.
8. Dial-up Modem or Cable Modem PC-to-Controller Communications:
- a. Communication software on the PC shall supervise the PC-to-controller communications link during dial-up modem connect times.
  - b. Communication software shall be programmable to routinely poll each of the remote dial-up or cable modem Locations, collecting event logs and verifying phone lines at operator-selectable time intervals for each Location.
  - c. System shall be programmable for dialing and connecting to all dial-up or cable modem Locations and for retrieving the accrued history transactions on an automatic basis as often as once every 10 minutes and up to once every 9999 minutes.
  - d. Failure to communicate to a dial-up Location three times in a row shall result in an alarm at the PC.
  - e. Time offset capabilities shall be present so that Locations in a different geographical time zone than the host PC will be set to, and maintained at, the proper local time. This feature shall allow for geographical time zones that are ahead of or behind the host PC.
  - f. The controller connected to a dial-up or cable modem shall automatically buffer all normal transactions until its buffer reaches 80 percent of capacity. When the transaction buffer reaches 80 percent, the controller shall automatically initiate a call to the central station and upload all transactions.
  - g. Alarms shall be reported immediately.
  - h. Dial-up or cable modems shall be provided by manufacturer of the system. Modems used at the controller shall be powered by the controller. Power to the modem shall include battery backup if the controller is so equipped.
9. Controller-to-Controller Communications:
- a. TIA 485-A, four-wire, point-to-point, regenerative (repeater) communications network methodology.
  - b. TIA 485-A communications signal shall be regenerated at each controller.
10. Database Downloads:
- a. All data transmissions from PCs to a Location, and between controllers at a Location, shall include a complete database checksum to check the integrity of the transmission. If the data checksum does not match, a full data download shall be automatically retransmitted.
  - b. If a controller is reset for any reason, it shall automatically request and receive a database download from the PC. The download shall restore data stored at the controller to their normal working state and shall take place with no operator intervention.

- c. Software shall provide for setting downloads via dial-up connection to once per 24-hour period, with time selected by the operator.
- d. Software shall provide for setting delays of database downloads for dial-up connections. Delays change the download from immediately to a delay ranging from one to 999 minutes.
- 11. Operator Interface:
  - a. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
  - b. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon to display the current system state in real time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
  - c. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.
  - d. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
  - e. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
  - f. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:
    - 1) Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
    - 2) Maps to provide real-time display animation and allow for control of points assigned to them.
    - 3) System to allow inputs, outputs, and override groups to be placed on different maps.
    - 4) Software to allow changing the order or priority in which maps will be displayed.
  - g. Override Groups Containing I/Os:
    - 1) System shall incorporate override groups that provide the operator with the status and control over user-defined "sets" of I/Os with a single icon.
    - 2) Icon shall change automatically to show the live summary status of points in that group.
    - 3) Override group icon shall provide a method to manually control or set to time-zone points in the group.
    - 4) Override group icon shall allow the expanding of the group to show icons representing the live status for each point in the group, individual control over each point, and the ability to compress the individual icons back into one summary icon.
  - h. Schedule Overrides of I/Os and Override Groups:
    - 1) To accommodate temporary schedule changes that do not fall within the holiday parameters, the operator shall have the ability to override schedules individually for each input, output, or override group.
    - 2) Each schedule shall be composed of a minimum of two dates with separate times for each date.
    - 3) The first time and date shall be assigned the override state that the point shall advance to when the time and date become current.
    - 4) The second time and date shall be assigned the state that the point shall return to when the time and date become current.
  - i. Copy command in database shall allow for like data to be copied and then edited for specific requirements, to reduce redundant data entry.
- 12. Operator Access Control:
  - a. Control operator access to system controls through three password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.
  - b. Three successive attempts by an operator to execute functions beyond their defined level during a 24-hour period shall initiate a software tamper alarm.
  - c. A minimum of 32 passwords shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.



- d. The password shall not be displayed or printed.
- e. Each password shall be definable and assignable for the following:
  - 1) Selected commands to be usable.
  - 2) Access to system software.
  - 3) Access to application software.
  - 4) Individual zones that are to be accessed.
  - 5) Access to database.
- 13. Operator Commands:
  - a. Command Input: Plain-language words and acronyms shall allow operators to use the system without extensive training or data-processing backgrounds. System prompts shall be a word, a phrase, or an acronym.
  - b. Command inputs shall be acknowledged and processing shall start in not less than one second(s).
  - c. Tasks that are executed by operator's commands shall include the following:
    - 1) Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
    - 2) Place Zone in Access: Used to remotely disable intrusion-alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
    - 3) Place Zone in Secure: Used to remotely activate intrusion-alarm circuits emanating from a specific zone.
    - 4) System Test: Allows the operator to initiate a system-wide operational test.
    - 5) Zone Test: Allows the operator to initiate an operational test for a specific zone.
    - 6) Print reports.
    - 7) Change Operator: Used for changing operators.
    - 8) Security Lighting Controls: Allows the operator to remotely turn on or turn off security lights.
    - 9) Display Graphics: Used to show any graphic displays implemented in the system. Graphic displays shall be completed within 20 seconds from time of operator command.
    - 10) Run system tests.
    - 11) Generate and format reports.
    - 12) Request help with the system operation.
      - a) Include in main menus.
      - b) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
      - c) Provide navigation to specific topic from within the first help window.
      - d) Help shall be accessible outside the application program.
  - 13) Entry-Control Commands:
    - a) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
    - b) Arm or disarm each monitored input up to four times a day through time-zone programming.
    - c) Enable or disable readers or keypads up to two times a day through time-zone programming.
    - d) Enable or disable cards or codes up to four times a day per entry point through access-level programming.
  - d. Command Input Errors: Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:
    - 1) Command entered is incorrect or incomplete.
    - 2) Operator is restricted from using that command.
    - 3) Command addresses a point that is disabled or out of service.

- 4) Command addresses a point that does not exist.
  - 5) Command is outside the system's capacity.
14. Alarms:
  - a. System Setup:
    - 1) Assign manual and automatic responses to incoming-point status change or alarms.
    - 2) Automatically respond to input with a link to other inputs, outputs, or operator-response plans; unique sound with use of WAV files; and maps or images that graphically represent the point location.
    - 3) Sixty-character message field for each alarm.
    - 4) Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 32,000 messages. Setup shall assign messages to access point **OR** zone **OR** sensor, **as directed**.
    - 5) Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
    - 6) Allow 25 secondary messages with a field of four lines of 60 characters each.
    - 7) Store the most recent 1000 alarms for recall by the operator using the report generator.
  - b. Software Tamper:
    - 1) Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
    - 2) Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond the authorization level.
    - 3) Maintain a transcript file of the last 5000 commands entered at each central station to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
    - 4) Allow only acknowledgment of software tamper alarms.
  - c. Read access to system transcript files shall be reserved for operators with the highest password authorization level available in system.
  - d. Animated Response Graphics: Highlight alarms with flashing icons on graphic maps; display and constantly update the current status of alarm inputs and outputs in real time through animated icons.
  - e. Multimedia Alarm Annunciation: WAV files to be associated with alarm events for audio annunciation or instructions.
  - f. Alarm Handling: Each input may be configured so that an alarm cannot be cleared unless it has returned to normal, with options of requiring the operator to enter a comment about disposition of alarm. Allow operator to silence alarm sound when alarm is acknowledged.
  - g. Alarm Automation Interface: High-level interface to central-station alarm automation software systems. Allows input alarms to be passed to and handled by automation systems in the same manner as burglar alarms, using a TIA 232-F ASCII interface.
  - h. CCTV Alarm Interface: Allow commands to be sent to CCTV systems during alarms (or input change of state) through serial ports.
  - i. Camera Control: Provides operator ability to select and control cameras from graphic maps.
15. Alarm Monitoring: Monitor sensors, controllers, and DTS circuits and notify operators of an alarm condition. Display higher-priority alarms first and, within alarm priorities, display the oldest unacknowledged alarm first. Operator acknowledgment of one alarm shall not be considered acknowledgment of other alarms nor shall it inhibit reporting of subsequent alarms.
  - a. Displayed alarm data shall include type of alarm, location of alarm, and secondary alarm messages.
  - b. Printed alarm data shall include type of alarm, location of alarm, date and time (to nearest second) of occurrence, and operator responses.
  - c. Maps shall automatically display the alarm condition for each input assigned to that map if that option is selected for that input location.



- d. Alarms initiate a status of "pending" and require the following two handling steps by operators:
    - 1) First Operator Step: "Acknowledged." This action shall silence sounds associated with the alarm. The alarm remains in the system "Acknowledged" but "Un-Resolved."
    - 2) Second Operator Step: Operators enter the resolution or operator comment, giving the disposition of the alarm event. The alarm shall then clear.
  - e. Each workstation shall display the total pending alarms and total unresolved alarms.
  - f. Each alarm point shall be programmable to disallow the resolution of alarms until the alarm point has returned to its normal state.
  - g. Alarms shall transmit to the central station in real time except for allowing connection time for dial-up locations.
  - h. Alarms shall be displayed and managed from a minimum of four different windows.
    - 1) Input Status Window: Overlay status icon with a large red blinking icon. Selecting the icon will acknowledge the alarm.
    - 2) History Log Transaction Window: Display name, time, and date in red text. Selecting red text will acknowledge the alarm.
    - 3) Alarm Log Transaction Window: Display name, time, and date in red. Selecting red text will acknowledge the alarm.
    - 4) Graphic Map Display: Display a steady colored icon representing each alarm input location. Change icon to flashing red when the alarm occurs. Change icon from flashing red to steady red when the alarm is acknowledged.
  - i. Once an alarm is acknowledged, the operator shall be prompted to enter comments about the nature of the alarm and actions taken. Operator's comments may be manually entered or selected from a programmed predefined list, or a combination of both.
  - j. For locations where there are regular alarm occurrences, provide programmed comments. Selecting that comment shall clear the alarm.
  - k. The time and name of the operator who acknowledged and resolved the alarm shall be recorded in the database.
  - l. Identical alarms from the same alarm point shall be acknowledged at the same time the operator acknowledges the first alarm. Identical alarms shall be resolved when the first alarm is resolved.
  - m. Alarm functions shall have priority over downloading, retrieving, and updating database from workstations and controllers.
  - n. When a reader-controlled output (relay) is opened, the corresponding alarm point shall be automatically bypassed.
16. Monitor Display: Display text and graphic maps that include zone status integrated into the display. Colors are used for the various components and current data. Colors shall be uniform throughout the system.
- a. Color Code:
    - 1) FLASHING RED: Alerts operator that a zone has gone into an alarm or that primary power has failed.
    - 2) STEADY RED: Alerts operator that a zone is in alarm and alarm has been acknowledged.
    - 3) YELLOW: Advises operator that a zone is in access.
    - 4) GREEN: Indicates that a zone is secure and that power is on.
  - b. Graphics:
    - 1) Support 32,000 graphic display maps and allow import of maps from a minimum of 16 standard formats from another drawing or graphics program.
    - 2) Allow I/O to be placed on graphic maps by the drag-and-drop method.
    - 3) Operators shall be able to view the inputs, outputs, and the point's name by moving the mouse cursor over the point on the graphic map.
    - 4) Inputs or outputs may be placed on multiple graphic maps. The operator shall be able to toggle to view graphic maps associated with I/Os.

- 5) Each graphic map shall have a display-order sequence number associated with it to provide a predetermined order when toggled to different views.
  - 6) Camera icons shall have the ability to be placed on graphic maps that, when selected by an operator, will open a video window, display the camera associated with that icon, and provide pan-tilt-zoom control.
  - 7) Input, output, or camera placed on a map shall allow the ability to arm or bypass an input, open or secure an output, or control the pan-tilt-zoom function of the selected camera.
17. System test software enables operators to initiate a test of the entire system or of a particular portion of the system.
- a. Test Report: The results of each test shall be stored for future display or printout. The report shall document the operational status of system components.
18. Report-Generator Software: Include commands to generate reports for displaying, printing, and storing on disk and tape. Reports shall be stored by type, date, and time. Report printing shall be the lowest-priority activity. Report-generation mode shall be operator selectable but set up initially as periodic, automatic, or on request. Include time and date printed and the name of operator generating the report. Report formats may be configured by operators.
- a. Automatic Printing: Setup shall specify, modify, or inhibit the report to be generated; the time the initial report is to be generated; the time interval between reports; the end of the period; and the default printer.
  - b. Printing on Request: An operator may request a printout of any report.
  - c. Alarm Reports: Reporting shall be automatic as initially set up. Include alarms recorded by system over the selected time and information about the type of alarm such as door alarm, intrusion alarm, tamper alarm, etc, the type of sensor, the location, the time, and the action taken.
  - d. Access and Secure Reports: Document zones placed in access, the time placed in access, and the time placed in secure mode.
  - e. Custom Reports: Reports tailored to exact requirements of who, what, when, and where. As an option, custom report formats may be stored for future printing.
  - f. Automatic History Reports: Named, saved, and scheduled for automatic generation.
  - g. Cardholder Reports: Include data, or selected parts of the data, as well as the ability to be sorted by name, card number, imprinted number, or by any of the user-defined fields.
  - h. Cardholder by Reader Reports: Based on who has access to a specific reader or group of readers by selecting the readers from a list.
  - i. Cardholder by Access-Level Reports: Display everyone that has been assigned to the specified access level.
  - j. Who Is "In" (Muster) Report:
    - 1) Emergency Muster Report: One-click operation on toolbar launches report.
    - 2) Cardholder Report. Contain a count of persons who are "In" at a selected Location and a detailed listing of name, date, and time of last use, sorted by the last reader used or by the group assignment.
  - k. Panel Labels Reports: Printout of control-panel field documentation including the actual location of equipment, programming parameters, and wiring identification. Maintain system installation data within system database so that data are available on-site at all times.
  - l. Activity and Alarm On-Line Printing: Activity printers for use at workstations; prints all events, or alarms only.
  - m. History Reports: Custom reports that allow the operator to select any date, time, event type, device, output, input, operator, Location, name, or cardholder to be included or excluded from the report.
    - 1) Initially store history on the hard disk of the host PC.
    - 2) Permit viewing of the history on workstations or print history to any system printer.
    - 3) The report shall be definable by a range of dates and times with the ability to have a daily start and stop time over a given date range.
    - 4) Each report shall depict the date, time, event type, event description, and device; or I/O name, cardholder group assignment, and cardholder name or code number.



- 5) Each line of a printed report shall be numbered to ensure that the integrity of the report has not been compromised.
- 6) Total number of lines of the report shall be given at the end of the report. If the report is run for a single event such as "Alarms," the total shall reflect how many alarms occurred during that period.
- n. Reports shall have the following four options:
  - 1) View on screen.
  - 2) Print to system printer. Include automatic print spooling and "Print To" options if more than one printer is connected to the system.
  - 3) "Save to File" with full path statement.
  - 4) System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.
- o. Custom Code List Subroutine: Allow the access codes of system to be sorted and printed according to the following criteria:
  - 1) Active, inactive, or future activate or deactivate.
  - 2) Code number, name, or imprinted card number.
  - 3) Group, Location access levels.
  - 4) Start and stop code range.
  - 5) Codes that have not been used since a selectable number of days.
  - 6) In, out, or either status.
  - 7) Codes with trace designation.
- p. The reports of system database shall allow options so that every data field may be printed.
- q. The reports of system database shall be constructed so that the actual position of the printed data shall closely match the position of the data on the data-entry windows.
19. Anti-Passback:
  - a. System shall have global and local anti-passback features, selectable by Location. System shall support hard and soft anti-passback.
  - b. Hard Anti-Passback: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes through a reader of opposite designation.
  - c. Soft Anti-Passback: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder and the door involved in the violation. A separate report may be run on this event.
  - d. Timed Anti-Passback: A controller capability that prevents an access code from being used twice at the same device (door) within a user-defined amount of time.
  - e. Provide four separate zones per Location that can operate without requiring interaction with the host PC (done at controller). Each reader shall be assignable to one or all four anti-passback zones. In addition, each anti-passback reader can be further designated as "Hard," "Soft," or "Timed" in each of the four anti-passback zones. The four anti-passback zones shall operate independently.
  - f. The anti-passback schemes shall be definable for each individual door.
  - g. The Master Access Level shall override anti-passback.
  - h. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential-holder population anti-passback status to a neutral status.
20. Visitor Assignment:
  - a. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only those access levels that have been designated as approved for visitors.
  - b. Provide an automated log of visitor name, time and doors accessed, and name of person contacted.
  - c. Allow a visitor designation to be assigned to a credential holder.

- d. Security access system shall be able to restrict the access levels that may be assigned to credentials issued to visitors.
  - e. Allow operator to recall visitors' credential-holder file once a visitor is enrolled in the system.
  - f. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.
  - g. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.
21. Time and Attendance:
- a. Time and attendance reporting shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
  - b. Shall be provided to match IN and OUT reads and display cumulative time in for each day and cumulative time in for length designated in the report.
  - c. System software setup shall allow designation of selected access-control readers as time and attendance hardware to gather the clock-in and clock-out times of the users at these readers.
    - 1) Reports shall show in and out times for each day, total time in for each day, and a total time in for period specified by the user.
    - 2) Allow the operator to view and print the reports, or save the reports to a file.
    - 3) Alphabetically sort reports on the person's last name, by Location or location group. Include all credential holders or optionally select individual credential holders for the report.
22. Training Software: Enables operators to practice system operation, including alarm acknowledgment, alarm assessment, response force deployment, and response force communications. System shall continue normal operation during training exercises and shall terminate exercises when an alarm signal is received at the console.
23. Entry-Control Enrollment Software: Database management functions that allow operators to add, delete, and modify access data as needed.
- a. The enrollment station shall not have alarm response or acknowledgment functions.
  - b. Provide multiple, password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.
  - c. The program shall provide means to disable the enrollment station when it is unattended, to prevent unauthorized use.
  - d. The program shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations. In the case of personnel identity-verification subsystems, this shall include biometric data. Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.
  - e. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:
    - 1) MASK: Determines a specific format with which data must comply.
    - 2) REQUIRED: Operator is required to enter data into field before saving.
    - 3) UNIQUE: Data entered must be unique.
    - 4) DEACTIVATE DATE: Data entered will be evaluated as an additional deactivate date for all cards assigned to this cardholder.
    - 5) NAME ID: Data entered will be considered a unique ID for the cardholder.
  - f. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.
  - g. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.





- h. Batch card printing.
- i. Default card data can be programmed to speed data entry for sites where most card data are similar.
- j. Enhanced ASCII File Import Utility: Allows the importing of cardholder data and images.
- k. Card Expire Function: Allows readers to be configured to deactivate cards when a card is used at selected devices.

D. System Database

1. Database and database management software shall define and modify each point in database using operator commands. Definition shall include parameters and constraints associated with each system device.
2. Database Operations:
  - a. System data management shall be in a hierarchical menu tree format, with navigation through expandable menu branches and manipulated with use of menus and icons in a main menu and system toolbar.
  - b. Navigational Aids:
    - 1) Toolbar icons for add, delete, copy, print, capture image, activate, deactivate, and muster report.
    - 2) Point and click feature to facilitate data manipulation.
    - 3) Next and previous command buttons visible when editing database fields to facilitate navigation from one record to the next.
    - 4) Copy command and copy tool in the toolbar to copy data from one record to create a new similar record.
  - c. Data entry shall be automatically checked for duplicate and illegal data and shall verify that data are in a valid format.
  - d. System shall generate a memo or note field for each item that is stored in database, allowing the storing of information about any defining characteristics of the item. Memo field is used for noting the purpose the item was entered for, reasons for changes that were made, and the like.
3. File Management:
  - a. File management shall include backup and restoration system, allowing selection of storage media, including 3.5-inch floppy disk, Zip and Jaz drives, and designated network resources.
  - b. Operations shall be both manual and automatic mode. The number of automatic sequential backups before the oldest backup becomes overwritten; FIFO mode shall be operator selectable.
  - c. Backup program shall provide manual operation from any PC on the LAN and shall operate while system remains operational.
4. Operator Passwords:
  - a. Software shall support up to 32,000 individual system operators, each with a unique password.
  - b. One to eight alphanumeric characters.
  - c. Allow passwords to be case sensitive.
  - d. Passwords shall not be displayed when entered.
  - e. Passwords shall have unique and customizable password profile, and allow several operators to share a password profile. Include the following features in the password profile:
    - 1) Allow for at least 32,000 operator password profiles.
    - 2) Predetermine the highest-level password profile for access to all functions and areas of program.
    - 3) Allow or disallow operator access to any program operation, including the functions of View, Add, Edit, and Delete.
    - 4) Restrict which doors an operator can assign access to.

- f. Operators shall use a user name and password to log on to system. This user name and password shall be used to access database areas and programs as determined by the associated profile.
  - g. Make provision to allow the operator to log off without fully exiting program. User may be logged off but program will remain running while displaying the login window for the next operator.
- 5. Access Card/Code Operation and Management: Access authorization shall be by card, by a manually entered code (PIN), or by a combination of both (card plus PIN).
  - a. Access authorization shall verify the facility code first, the card or card-and-PIN validation second, and the access level (time of day, day of week, date), anti-passback status, and number of uses last.
  - b. Use data-entry windows to view, edit, and issue access levels. Access authorization entry management system shall maintain and coordinate all access levels to prevent duplication or the incorrect creation of levels.
  - c. Allow assignment of multiple cards/codes to a cardholder.
  - d. Allow assignment of up to four access levels for each Location to a cardholder. Each access level may contain any combination of doors.
  - e. Each door may be assigned four time zones.
  - f. Access codes may be up to 11 digits in length.
  - g. Software shall allow the grouping of locations so cardholder data can be shared by all locations in the group.
  - h. Visitor Access: Issue a visitor badge for data tracking or photo ID purposes without assigning that person a card or code.
  - i. Cardholder Tracing: Allow for selection of cardholder for tracing. Make a special audible and visual annunciation at control station when a selected card or code is used at a designated code reader. Annunciation shall include an automatic display of the cardholder image.
  - j. Allow each cardholder to be given either an unlimited number of uses or a number from 1 to 9998 that regulates the number of times the card can be used before it is automatically deactivated.
  - k. Provide for cards and codes to be activated and deactivated manually or automatically by date. Provide for multiple deactivate dates to be preprogrammed.
- 6. Security Access Integration:
  - a. Photo ID badging and photo verification shall use same database as the security access and may query data from cardholder, group, and other personal information to build a custom ID badge.
  - b. Automatic or manual image recall and manual access based on photo verification shall also be a means of access verification and entry.
  - c. System shall allow sorting of cardholders together by group or other characteristic for a fast and efficient method of reporting on, and enabling or disabling, cards or codes.
- 7. Key control and tracking shall be an integrated function of cardholder data.
  - a. Provide the ability to store information about which conventional metal keys are issued and to whom, along with key construction information.
  - b. Reports shall be designed to list everyone that has possession of a specified key.
- 8. Facility Codes: System shall accommodate up to 2048 facility codes per Location, with the option of allowing facility codes to work at all doors or only particular doors.
- 9. Operator Comments:
  - a. With the press of one appropriate button on toolbar, the user shall be permitted to make operator comments into history at anytime.
  - b. Automatic prompting of operator comment shall occur before the resolution of each alarm.
  - c. Operator comments shall be recorded by time, date, and operator number.
  - d. Comments shall be sorted and viewed through reports and history.
  - e. The operator may enter comments in two ways; either or both may be used:
    - 1) Manually entered through keyboard data entry (typed), up to 65,000 characters per each alarm.
    - 2) Predefined and stored in database for retrieval on request.



- f. System shall have a minimum of 999 predefined operator comments with up to 30 characters per comment.
- 10. Group:
  - a. Group names may be used to sort cardholders into groups that allow the operator to determine the tenant, vendor, contractor, department, division, or any other designation of a group to which the person belongs.
  - b. System software shall have the capacity to assign 1 of 32,000 group names to an access authorization.
  - c. Make provision in software to deactivate and reactivate all access authorizations assigned to a particular group.
  - d. Allow sorting of history reports and code list printouts by group name.
- 11. Time Zones:
  - a. Each zone consists of a start and stop time for 7 days of the week and three holiday schedules. A time zone is assigned to inputs, outputs, or access levels to determine when an input shall automatically arm or disarm, when an output automatically opens or secures, or when access authorization assigned to an access level will be denied or granted.
  - b. Up to four time zones may be assigned to inputs and outputs to allow up to four arm or disarm periods per day or four lock or unlock periods per day; up to three holiday override schedules may be assigned to a time zone.
  - c. Data-entry window shall display a dynamically linked bar graph showing active and inactive times for each day and holiday, as start and stop times are entered or edited.
  - d. System shall have the capacity for 2048 time zones for each Location.
- 12. Holidays:
  - a. Three different holiday schedules may be assigned to a time zone. Holiday schedule consists of date in format MM/DD/YEAR and a description. When the holiday date matches the current date of the time zone, the holiday schedule replaces the time zone schedule for that 24-hour period.
  - b. System shall have the capacity for 32,000 holidays.
  - c. Three separate holiday schedules may be applied to a time zone.
  - d. Holidays have an option to be designated as occurring on the designated date each year. These holidays remain in system and will not be purged.
  - e. Holidays not designated to occur each year shall be automatically purged from database after the date expires.
- 13. Access Levels:
  - a. System shall allow for the creation up to 32,000 access levels.
  - b. One level shall be predefined as the Master Access Level. The Master Access Level shall work at all doors at all times and override any anti-passback.
  - c. System shall allow for access to be restricted to any area by reader and by time. Access levels shall determine when and where an Identifier is authorized.
  - d. System shall be able to create multiple door and time zone combinations under same access level so that an Identifier may be valid during different time periods at different readers even if the readers are on the same Controller.
- 14. User-Defined Fields:
  - a. System shall provide a minimum of 99 user-defined fields, each with up to 50 characters, for specific information about each credential holder.
  - b. System shall accommodate a title for each field; field length shall be 20 characters.
  - c. A "Required" option may be applied to each user-defined field that, when selected, forces the operator to enter data in the user-defined field before the credential can be saved.
  - d. A "Unique" option may be applied to each user-defined field that, when selected, will not allow duplicate data from different credential holders to be entered.
  - e. Data format option may be assigned to each user-defined field that will require the data to be entered with certain character types in specific spots in the field entry window.
  - f. A user-defined field, if selected, will define the field as a deactivate date. The selection shall automatically cause the data to be formatted with the windows MM/DD/YEAR date format. The credential of the holder will be deactivated on that date.

- g. A search function shall allow any one user-defined field or combination of user-defined fields to be searched to find the appropriate cardholder. The search function shall include search for a character string.
- h. System shall have the ability to print cardholders based on and organized by the user-defined fields.
15. Code Tracing:
- a. System shall perform code tracing selectable by cardholder and by reader.
- b. Any code may be designated as a "traced code" with no limit to how many codes can be traced.
- c. Any reader may be designated as a "trace reader" with no limit to which or how many readers can be used for code tracing.
- d. When a traced code is used at a trace reader, the access-granted message that usually appears on the monitor window of the Central Station shall be highlighted with a different color than regular messages. A short singular beep shall occur at the same time the highlighted message is displayed on the window.
- e. The traced cardholder image (if image exists) shall appear on workstations when used at a trace reader.
- E. Surge And Tamper Protection
1. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor-entry connection to components.
- a. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits".
- b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Division 26 Section "Transient-voltage Suppression For Low-voltage Electrical Power Circuits" as recommended by manufacturer for type of line being protected.
2. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station control-unit alarm display shall identify tamper alarms and indicate locations.
- F. Central-Station Hardware
1. Central-Station Computer: Standard unmodified PC of modular design. The CPU word size shall be 32 bytes or larger; the CPU operating speed shall be at least 66 MHz OR GHz, **as directed**.
- a. Memory: 256 MB of usable installed memory, expandable to a minimum of 1024 MB without additional chassis or power supplies.
- b. Power Supply: Minimum capacity of 250 W.
- c. Real-Time Clock:
- 1) Accuracy: Plus or minus 1 minute per month.
- 2) Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; resettable by software.
- 3) Clock shall function for 1 year without power.
- 4) Provide automatic time correction once every 24 hours by synchronizing clock with the Time Service Department of the U.S. Naval Observatory.
- d. Serial Ports: Provide two TIA 232-F serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
- e. Parallel Port: An enhanced parallel port.
- f. LAN Adapter Card: 10/100 Mbps PCI bus, internal network interface card.
- g. Sound Card: For playback and recording of digital WAV sound files that are associated with audible warning and alarm functions.
- h. Color Monitor: Not less than **17 inches (430 mm)**, with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm. The video card shall



- support at least 256 colors at a resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.
- i. Keyboard: With a minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
  - j. Mouse: Standard, compatible with the installed software.
  - k. Special function keyboard attachments or special function keys to facilitate data input of the following operator tasks:
    - 1) Help.
    - 2) Alarm Acknowledge.
    - 3) Place Zone in Access.
    - 4) Place Zone in Secure.
    - 5) System Test.
    - 6) Print Reports.
    - 7) Change Operator.
  - l. Disk storage shall include the following, each with appropriate controller:
    - 1) Minimum 10 GB hard disk, maximum average access time of 10 ms.
    - 2) Floppy Disk Drive: High density, 3-1/2-inch (90-mm) size.
    - 3) PCMCIA slot with removable 500 MB media.
    - 4) 100 MB Iomega Zip drive.
    - 5) 250 MB Iomega Jaz drive.
  - m. Magnetic Tape System: 4-mm cartridge magnetic tape system with minimum 2 **OR 4 OR 12 OR 20, as directed**, GB formatted capacity per tape. Provide 10 tapes, each in a rigid cartridge with spring-loaded cover and operator-settable write-protect feature.
  - n. Modem: 56,600 bps, full duplex for asynchronous communications. With error detection, auto answer/autodial, and call-in-progress detection. Modem shall comply with requirements in ITU-T v.34, ITU-T v.42 for error correction, and ITU-T v.42 BIS for data compression standards; and shall be suitable for operating on unconditioned voice-grade telephone lines complying with 47 CFR 68.
  - o. Audible Alarm: Manufacturer's standard.
  - p. CD-ROM Drive:
    - 1) Nominal storage capacity of 650 MB.
    - 2) Data Transfer Rate: 1.2 Mbps.
    - 3) Average Access Time: 150 ms.
    - 4) Cache Memory: 256 KB.
    - 5) Data Throughput: 1 MB/second, minimum.
  - q. Dot Matrix Alarm Printer:
    - 1) Connected to the Central Station.
    - 2) Minimum of 96 characters, standard ASCII character set based on ANSI INCITS 154, and with graphics capability and programmable control of top-of-form.
    - 3) Prints in both red and black without ribbon change.
    - 4) Adjustable sprockets for paper width up to 11 inches.
    - 5) 80 columns per line, minimum speed of 200 characters per second.
    - 6) Character Spacing: Selectable at 10, 12, or 17 characters per inch.
    - 7) Paper: Sprocket-fed fan fold paper.
  - r. Report Printer:
    - 1) Connected to the Central Station and designated workstations.
    - 2) Laser printer with minimum resolution of 600 dpi.
    - 3) RAM: 2 MB, minimum.
    - 4) Printing Speed: Minimum 12 pages per minute.
    - 5) Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.
  - s. Interface: Bidirectional parallel and universal serial bus.
  - t. LAN Adapter Card: 10/100 Mbps internal network interface card.
2. Redundant Central Computer: One identical redundant central computer, connected in a hot standby, peer configuration. This computer shall automatically maintain its own copies of system

- software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant computer in near real-time. If central computer fails, redundant computer shall assume control immediately and automatically.
3. UPS: Self-contained; complying with requirements in Division 26 Section "Static Uninterruptible Power Supply".
    - a. Size: Provide a minimum of 6 hours of operation of the central-station equipment, including 2 hours of alarm printer operation.
    - b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
    - c. Accessories:
      - 1) Transient voltage suppression.
      - 2) Input-harmonics reduction.
      - 3) Rectifier/charger.
      - 4) Battery disconnect device.
      - 5) Static bypass transfer switch.
      - 6) Internal maintenance bypass/isolation switch.
      - 7) External maintenance bypass/isolation switch.
      - 8) Output isolation transformer.
      - 9) Remote UPS monitoring.
      - 10) Battery monitoring.
      - 11) Remote battery monitoring.
- G. Standard Workstation Hardware
1. Workstation shall consist of a standard unmodified PC, with accessories and peripherals that configure the workstation for a specific duty.
  2. Workstation Computer: Standard unmodified PC of modular design. The CPU word size shall be 32 bytes or larger; the CPU operating speed shall be at least 66 MHz **OR** GH, **as directed**.
    - a. Memory: 512 MB of usable installed memory, expandable to a minimum of 8 GB without additional chassis or power supplies.
    - b. Power Supply: Minimum capacity of 250 W.
    - c. Real-Time Clock:
      - 1) Accuracy: Plus or minus 1 minute per month.
      - 2) Time Keeping Format: 24-hour time format including seconds, minutes, hours, date, day, and month; resettable by software.
      - 3) Provide automatic time correction once every 24 hours by synchronizing clock with the Central Station.
    - d. Serial Ports: Provide two TIA 232-F USB serial ports for general use, with additional ports as required. Data transmission rates shall be selectable under program control.
    - e. Parallel Port: An enhanced parallel port.
    - f. Sound Card: For playback and recording of digital WMP sound files that are associated with audible warning and alarm functions.
    - g. Color Monitor: Not less than **17 inches (430 mm)**, with a minimum resolution of 1280 by 1024 pixels, noninterlaced, and a maximum dot pitch of 0.28 mm. The video card shall support at least 256 colors at a resolution of 1280 by 1024 at a minimum refresh rate of 70 Hz.
    - h. Keyboard: With a minimum of 64 characters, standard ASCII character set based on ANSI INCITS 154.
    - i. Mouse: Standard, compatible with the installed software. Minimum resolution shall be 400 dpi.
    - j. Disk storage shall include the following, each with appropriate controller:
      - 1) Minimum 20 GB hard disk, maximum average access time of 10 ms.
      - 2) Floppy Disk Drive: High density, **3-1/2-inch (90-mm)** size.
    - k. CD-ROM Drive:
      - 1) Nominal storage capacity of 700 MB.
      - 2) Data Transfer Rate: 3.6 Mbps.
      - 3) Average Access Time: 150 ms.
      - 4) Cache Memory: 512 KB.



- 5) Data Throughput: 3.6 MB/second, minimum.
- 6) Read Speed: 48x.
- 7) Write Speed: 32x.
- I. DVD/DVD-RW Drive:
  - 1) Nominal Storage Capacity: 4.7 GB.
  - 2) Data Transfer Rate: 3.6 Mbps.
  - 3) Cache Memory: 512 KB.
  - 4) Read Speed: 24x.
  - 5) Write Speed: 6x.
- m. Printer:
  - 1) Connected to the Central Station and designated workstations.
  - 2) Laser printer with minimum resolution of 600 dpi.
  - 3) RAM: 8 MB, minimum.
  - 4) Printing Speed: Minimum 12 pages per minute.
  - 5) Paper Handling: Automatic sheet feeder with 250-sheet paper cassette and with automatic feed.
- n. Interface: Bidirectional parallel, and universal serial bus.
- o. LAN Adapter Card: 10/100 Mbps internal network interface card.
3. Redundant Workstation: One identical redundant workstation, connected in a hot standby, peer configuration. This workstation shall automatically maintain its own copies of system software, application software, and data files. System transactions and other activities that alter system data files shall be updated to system files of redundant workstation in near real time. If its associated workstation fails, redundant workstation shall assume control immediately and automatically.
4. UPS: Self-contained, complying with requirements in Division 26 Section "Static Uninterruptible Power Supply".
  - a. Size: Provide a minimum of 6 hours of operation of the central-station equipment, including 2 hours of alarm printer operation.
  - b. Batteries: Sealed, valve regulated, recombinant, lead calcium.
  - c. Accessories:
    - 1) Transient voltage suppression.
    - 2) Input-harmonics reduction.
    - 3) Rectifier/charger.
    - 4) Battery disconnect device.
    - 5) Static bypass transfer switch.
    - 6) Internal maintenance bypass/isolation switch.
    - 7) External maintenance bypass/isolation switch.
    - 8) Output isolation transformer.
    - 9) Remote UPS monitoring.
    - 10) Battery monitoring.
    - 11) UPS operation monitoring.
    - 12) Abnormal operation. Visible and audible indication.
    - 13) Remote battery monitoring.
- H. Communications Workstation
  1. Standard workstation, modified as follows:
    - a. Additional TIA 232-F serial ports. The CPU word size shall be 32 bytes or larger; the CPU operating speed shall be at least 66 MHz. Multiplexed serial ports shall be expandable with 8 character transmit and receive buffers for each port. Total buffer size shall be a minimum of 1 MB.
    - b. Redundant workstation is not required.
    - c. Printer is not required.
  - I. Fixed Map Display: A fixed map display shall show layout of the protected facilities. Zones corresponding to those monitored by system shall be highlighted on the display. Status of each zone

shall be displayed using LEDs as required within each designated zone. An LED test switch shall be provided on the map display.

J. Controllers

1. Controllers: Intelligent peripheral control unit, complying with UL 294, that stores time, date, valid codes, access levels, and similar data downloaded from the Central Station or workstation for controlling its operation.
2. Subject to compliance with requirements in this Article, manufacturers may use multipurpose Controllers.
3. Battery Backup: Sealed, lead acid; sized to provide run time during a power outage of 90 minutes, complying with UL 924.
4. Alarm Annunciation Controller:
  - a. The Controller shall automatically restore communication within 10 seconds after an interruption with the field device network with dc line supervision on each of its alarm inputs.
    - 1) Inputs: Monitor dry contacts for changes of state that reflect alarm conditions. Provides at least eight alarm inputs, which are suitable for wiring as normally open or normally closed contacts for alarm conditions.
    - 2) Alarm-Line Supervision:
      - a) Supervise the alarm lines by monitoring each circuit for changes or disturbances in the signal, and for conditions as described in UL 1076 for line security equipment **OR** by monitoring for abnormal open, grounded, or shorted conditions, **as directed**, using dc change measurements. System shall initiate an alarm in response to an abnormal current, which is a dc change of 5 **OR** 10, **as directed**, percent or more for longer than 500 ms.
      - b) Transmit alarm-line-supervision alarm to the Central Station during the next interrogation cycle after the abnormal current condition.
    - 3) Outputs: Managed by Central Station software.
  - b. Auxiliary Equipment Power: A GFI service outlet inside the Controller enclosure.
5. Entry-Control Controller:
  - a. Function: Provide local entry-control functions including one- and two-way communications with access-control devices such as card readers, keypads, biometric personal identity verification devices, door strikes, magnetic latches, gate and door operators, and exit push-buttons.
    - 1) Operate as a stand-alone portal Controller using the downloaded database during periods of communication loss between the Controller and the field-device network.
    - 2) Accept information generated by the entry-control devices; automatically process this information to determine valid identification of the individual present at the portal:
      - a) On authentication of the credentials or information presented, check privileges of the identified individual, allowing only those actions granted as privileges.
      - b) Privileges shall include, but not be limited to, time of day control, day of week control, group control, and visitor escort control.
    - 3) Maintain a date-, time-, and Location-stamped record of each transaction. A transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
  - b. Inputs:
    - 1) Data from entry-control devices; use this input to change modes between access and secure.
    - 2) Database downloads and updates from the Central Station that include enrollment and privilege information.
  - c. Outputs:
    - 1) Indicate success or failure of attempts to use entry-control devices and make comparisons of presented information with stored identification information.
    - 2) Grant or deny entry by sending control signals to portal-control devices and mask intrusion alarm annunciation from sensors stimulated by authorized entries.





- 3) Maintain a date-, time-, and Location-stamped record of each transaction and transmit transaction records to the Central Station.
  - 4) Door Prop Alarm: If a portal is held open for longer than 20 seconds **OR** time listed in a schedule, **as directed**, alarm sounds.
  - d. With power supplies sufficient to power at voltage and frequency required for field devices and portal-control devices.
  - e. Data Line Problems: For periods of loss of communications with Central Station, or when data transmission is degraded and generating continuous checksum errors, the Controller shall continue to control entry by accepting identifying information, making authentication decisions, checking privileges, and controlling portal-control devices.
    - 1) Store up to 1000 transactions during periods of communication loss between the Controller and access-control devices for subsequent upload to the Central Station on restoration of communication.
  - f. Controller Power: NFPA 70, Class II power supply transformer, with 12- or 24-V ac secondary, backup battery and charger.
    - 1) Backup Battery: Premium, valve-regulated, recombinant-sealed, lead-calcium battery; spill proof; with a full 1-year warranty and a pro rata 19-year warranty. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
    - 2) Backup Battery: Valve-regulated, recombinant-sealed, lead-acid battery; spill proof. With single-stage, constant-voltage-current, limited battery charger, comply with battery manufacturer's written instructions for battery terminal voltage and charging current recommendations for maximum battery life.
    - 3) Backup Power Supply Capacity: 5 **OR** 90, **as directed**, minutes of battery supply. Submit battery and charger calculations.
    - 4) Power Monitoring: Provide manual dynamic battery load test, initiated and monitored at the control center; with automatic disconnection of the Controller when battery voltage drops below Controller limits. Report by using local Controller-mounted LEDs and by communicating status to Central Station. Indicate and report the following:
      - a) Trouble Alarm: Normal power off load assumed by battery.
      - b) Trouble Alarm: Low battery.
      - c) Alarm: Power off.
- K. Secondary Alarm Annunciator
1. Secondary Alarm Annunciation Site: A workstation with limited I/O capacity, consisting of a secondary alarm annunciation workstation to allow the operator to duplicate functions of the main operator interface, and to show system status changes **OR** to display alarms or system status changes only, **as directed**.
- L. Card Readers, Credential Cards, And Keypads
1. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
  2. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.
  3. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:
    - a. Indoors, controlled environment.
    - b. Indoors, uncontrolled environment.
    - c. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.

4. Display: Digital visual indicator shall provide visible and audible status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.
5. Stripe Swipe Readers: Bidirectional, reading cards swiped in both directions, powered by the controller. Reader shall be set up for ABA Track.
  - a. ABA Track: Magnetic stripe that is encoded on track 2, at 75-bpi density in binary-coded decimal format; for example, 5-bit, 16-character set.
  - b. Readers for outdoors shall be in a polymeric plastic enclosure with all electronics potted in plastic. Rated for operation in ambient conditions of **minus 40 to plus 160 deg F (minus 40 to plus 70 deg C)** in a humidity range of 10 to 90 percent.
6. Wiegand Swipe Reader: Set up for 33 **OR** 26-bit data cards, **as directed**. Comply with SIA AC-01.
7. Wiegand Key-Insert Reader: Set up for 33 **OR** 26-bit data cards, **as directed**.
8. Bar-Code Reader: Set up for Code 39 **OR** 93 **OR** 128, **as directed**.
9. Insert Readers: Requiring the card to be inserted from the bottom **OR** side, **as directed**, powered by the controller.
10. Touch-Plate and Proximity Readers:
  - a. Active-detection proximity card readers shall provide power to compatible credential cards through magnetic induction, and shall receive and decode a unique identification code number transmitted from the credential card.
  - b. Passive-detection proximity card readers shall use a swept-frequency, RF field generator to read the resonant frequencies of tuned circuits laminated into compatible credential cards. The resonant frequencies read shall constitute a unique identification code number.
  - c. The card reader shall read proximity cards in a range from direct contact to at least **6 inches (150 mm)** from the reader.
11. Keypads:
  - a. Entry-control keypads shall use a unique combination of alphanumeric and other symbols as an Identifier.
  - b. Keypads shall contain an integral alphanumeric/special symbols keyboard with symbols arranged in ascending ASCII-code ordinal sequence **OR** random scrambled order, **as directed**.
  - c. Communication protocol shall be compatible with the local processor.
12. Keypad Display:
  - a. Keypads shall include a digital visual indicator and shall provide visible **OR** visible and audible status indications and user prompts, **as directed**.
  - b. Display shall indicate power on or off and whether user passage requests have been accepted or rejected.
  - c. Design of the keypad display or keypad enclosure shall limit viewing angles of the keypad as follows:
    - 1) Maximum Horizontal Viewing Angle: Plus or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
    - 2) Maximum Vertical Viewing Angle: Plus or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.
13. Keypad Response Time:
  - a. The keypad shall respond to passage requests by generating a signal to the local processor. The response time shall be 800 ms or less from the time the last alphanumeric symbol is entered until a response signal is generated.
14. Keypad Power:
  - a. The keypad shall be powered from the source as shown and shall not dissipate more than 150 W.
15. Keypad Mounting Method:
  - a. Keypads shall be suitable for surface, semi-flush, pedestal, or weatherproof mounting as required.
16. Keypad Duress Codes:
  - a. Keypads shall provide a means for users to indicate a duress situation by entering a special code.



17. Keypad and Wiegand-Swipe-Reader Combination: Designed to require an entry on the keypad before presenting the credential card.
  - a. Keypad: Allow the entry of four numeric digits **OR** alphanumeric characters, **as directed**, that are associated with a specific credential. Keypads shall contain an integral alphanumeric/special symbol keyboard with symbols arranged in ascending ASCII-code ordinal sequence **OR** random scrambled order, **as directed**. Keypad display or enclosure shall limit viewing angles of the keypad as follows:
    - 1) Maximum Horizontal Viewing Angle: Plus or minus 5 degrees or less off a vertical plane perpendicular to the plane of the face of the keypad display.
    - 2) Maximum Vertical Viewing Angle: Plus or minus 15 degrees or less off a horizontal plane perpendicular to the plane of the face of the keypad display.
  - b. Wiegand Swipe Reader: Set up for 33 OR 26-bit data cards, **as directed**, to generate a unique card identification code. Comply with SIA AC-01.
18. Communication Protocol: Compatible with local processor.
19. Touch-Plate and Contactless Card Reader: The reader shall have "flash" download capability to accommodate card format changes. The card reader shall have capability of transmitting data to security control panel and shall comply with ISO/IEC 7816.
20. Credential Card Modification: Entry-control cards shall be able to be modified by lamination direct print process during the enrollment process without reduction of readability. The design of the credential cards shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the badge holder used at the site.
21. Specify the standard card size of 2-1/8 by 3-3/8 inches (54 by 85 mm) unless a different size card is needed. If a nonstandard size card is specified, verify that the card size will work with the photo badging system and the card reader specified.
22. Card Size and Dimensional Stability: Credential cards shall be **2-1/8 by 3-3/8 inches (54 by 86 mm)**. The credential card material shall be dimensionally stable so that an undamaged card with deformations resulting from normal use shall be readable by the card reader.
23. Card Material: Abrasion resistant, nonflammable, nontoxic, and impervious to solar radiation and effects of ultraviolet light.
24. Insert additional security enhancements in paragraph below if needed. Retain card lamination and assembly equipment if needed at the site.
25. Card Construction:
  - a. Core and laminate or monolithic construction.
  - b. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
  - c. Incorporate holographic images **OR** phosphorous ink, **as directed**, as a security enhancement.
  - d. Furnish equipment for on-site assembly and lamination of credential cards.
- M. Biometric Identity Verification Equipment
  1. Biometric identity verification templates shall be stored as part of system database files and used as a comparative base by the identity verification equipment to generate an appropriate signal to the associated Controller.
  2. Eye Retina Scanner: Designed to incorporate positive measures to establish that the eye retina being scanned by the device belongs to a living human being.
    - a. Scanner shall not require eye contact with the retina scan equipment. Scan initiation shall be manual.
    - b. The efficiency and accuracy of scanner shall not be affected by contact lenses.
    - c. Storage space of each eye template shall not exceed 512 8-bit bytes.
    - d. Light-emitting source used for retina scans may not use light levels exceeding 20 percent of the maximum safe level established in the American Conference of Governmental Industrial Hygienists limit values.
    - e. Template Update: Eye scanner shall not automatically update a user's template. Significant changes in an individual's eye shall require re-enrollment.

- f. Scan acceptance tolerance or template match criteria shall be under system manager/operator control. Eye scanner shall determine automatically when multiple attempts are needed to verify the eye being scanned, prompting automatically for additional attempts, up to a maximum of three. Three failed attempts shall generate an entry-control alarm.
  - g. Time of Verification: Eye scanner shall respond to passage requests by generating an entry request signal to the Controller. The verification time shall be 1.5 seconds or less from the moment eye scanner initiates the scan process until eye scanner generates a response signal.
  - h. Modes: Eye scanner shall provide an enrollment mode, a recognition mode, and a code/credential verification mode.
    - 1) In the enrollment mode, eye scanner shall create an eye template for new personnel and enter the template into system database file created for that person. Template information shall be compatible with system application software.
    - 2) In the recognition mode, eye scanner shall allow passage when the eye scan data from the verification attempt match an eye template stored in database files.
    - 3) In the code/credential verification mode, eye scanner shall allow passage when the eye scan data from the verification attempt match the eye scan template associated with the identification code entered into a keypad, or they match the eye scan template associated with credential card data read by a card reader.
  - i. Reports: Eye scanner shall create and store template match scores for all transactions involving eye retinal scans. Template match scores shall be stored in the matching personnel data file used for report generation.
  - j. Power: Scanner shall be powered from its associated Controller, requiring not more than 45 W.
  - k. Enclosure: Eye scanners shall be available with enclosures that are suitable for surface, semiflush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
    - 1) Indoors, controlled environment.
    - 2) Indoors, uncontrolled environment.
  - l. Display: LED or other type of visual indicator display shall provide visual and audible status indications and user prompts. Indicate power on/off, and whether user passage requests have been accepted or rejected.
3. Hand Geometry: Use unique human hand measurements to identify authorized, enrolled personnel. The design of this device shall incorporate positive measures to establish that the hand being measured by the device belongs to a living human being.
- a. The user's hand shall remain in full view of the user at all times. The scan process of the hand geometry device shall make three-dimensional measurements of the size and shape of the subject's hand. Scanning shall start automatically once the user's hand is properly positioned by the alignment system.
  - b. Hand geometry device shall be able to use either left or right hand for enrollment and verification.
  - c. Storage space of each eye template shall not exceed 50 8-bit bytes.
  - d. Template Update and Acceptance Tolerances: Hand geometry devices shall not automatically update a user's profile. Significant changes in an individual's hand geometry shall require re-enrollment. Hand geometry devices shall provide an adjustable acceptance tolerance or template match criteria under system manager/operator control. Hand geometry device shall determine when multiple attempts are needed for hand geometry verification and shall automatically prompt the user for additional attempts up to a maximum of three. Three failed attempts shall generate an entry-control alarm.
  - e. Average Verification Time: Hand geometry device shall respond to passage requests by generating an entry request signal to the Controller. The verification time shall be 1.5 seconds or less from the moment hand geometry device initiates the scan process until hand geometry device generates a response signal.
  - f. Modes: Hand geometry device shall provide an enrollment mode, a recognition mode, and a code/credential verification mode.



- 1) In the enrollment mode, hand geometry device shall create a hand template for new personnel and enter the template into system database file created for that person. Template information shall be compatible with system application software.
- 2) In the recognition mode, hand geometry device shall allow passage when the hand scan data from the verification attempt match a hand geometry template stored in database files.
- 3) In the code/credential verification mode, hand geometry device shall allow passage when the hand scan data from the verification attempt match the hand geometry template associated with the identification code entered into a keypad, or they match the hand geometry template associated with credential card data read by a card reader.
- g. Reports: Hand geometry device shall create and store template match scores for all transactions involving hand geometry scans. Template match scores shall be stored in the matching personnel data file used for report generation.
- h. Power: Hand geometry device shall be powered from its associated Controller, requiring not more than 45 W.
- i. Enclosure: Geometry readers shall be available with enclosures that are suitable for surface, semiflush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
  - 1) Indoors, controlled environment.
  - 2) Indoors, uncontrolled environment.
  - 3) Outdoors.
- j. Display: LED or other type of visual indicator display shall provide visual and audible status indications and user prompts. Indicate power on/off, and whether user passage requests have been accepted or rejected.
4. Fingerprint Analysis Scanner: Use a unique human fingerprint pattern to identify authorized, enrolled personnel. The design of this device shall incorporate positive measures to establish that the hand or fingers being scanned by the device belong to a living human being.
  - a. The user's hand shall remain in full view of the user at all times. The scan process of the fingerprint analysis scanner shall perform an optical or other type of scan of the enrollee's fingers. Scanning shall start automatically when the user's fingers are properly positioned.
  - b. Storage space for each fingerprint template shall not require more than 1250 8-bit bytes.
  - c. Template Update and Acceptance Tolerances: Fingerprint analysis scanners shall not automatically update a user's profile. Significant changes in an individual's fingerprints shall require re-enrollment. Fingerprint analysis scanners shall provide an adjustable acceptance tolerance or template match criteria under system manager/operator control. Fingerprint analysis scanner shall determine when multiple attempts are needed for fingerprint verification and shall automatically prompt the enrollee for additional attempts up to a maximum of three. Three failed attempts shall generate an entry-control alarm.
  - d. Average Verification Time: Fingerprint analysis scanner shall respond to passage requests by generating an entry request signal to the Controller. The verification time shall be 2 seconds or less from the moment fingerprint analysis scanner initiates the scan process until fingerprint analysis scanner generates a response signal.
  - e. Modes: Fingerprint analysis scanner shall provide an enrollment mode, a recognition mode, and a code/credential verification mode.
    - 1) In the enrollment mode, fingerprint analysis scanner shall create a fingerprint template for new personnel and enter the template into the system database file created for that person.
    - 2) In the recognition mode, fingerprint analysis scanner shall allow passage when the fingerprint data from the verification attempt match a fingerprint template stored in database files.
    - 3) In the code/credential verification mode, fingerprint analysis scanner shall allow passage when the fingerprint data from the verification attempt match the fingerprint template associated with the identification code entered into a keypad, or they match the fingerprint template associated with credential card data read by a card reader.

- f. Reports: Fingerprint analysis device shall create and store pattern match scores for all transactions involving fingerprint scans. Template match scores shall be stored in the matching personnel data file used for report generation.
  - g. Power: Fingerprint analysis scanner shall be powered from its associated Controller, requiring not more than 45 W.
  - h. Enclosure: Scanners shall be available with enclosures that are suitable for surface, semiflush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
    - 1) Indoors, controlled environment.
    - 2) Indoors, uncontrolled environment.
    - 3) Outdoors.
  - i. Display: LED or other type of visual indicator display shall provide visual and audible status indications and user prompts. Indicate power on/off, and whether user passage requests have been accepted or rejected.
5. Iris Scan Device: Use the unique patterns found in the iris of the human eye to identify authorized, enrolled personnel. The device shall use ambient light to capture an image of the iris of a person for identification. The resulting video image shall be compared against a stored template that was captured during the enrollment process. When the presented image is sufficiently similar to the stored image template, then the device shall authenticate the presenting individual as identified. The threshold of similarity shall be adjustable.
- a. Enrollees who wear contact lenses or eyeglasses shall not adversely affect the efficiency and accuracy of the device.
  - b. Iris scan device shall provide a means for enrollees to align their eye for identification that does not require facial contact with the device. A manual push-button shall be provided to initiate the scan process when the enrollee's eye is aligned in front of the device.
  - c. The device shall include adjustments to accommodate differences in enrollee height.
  - d. Template Update: Iris scanners shall not automatically update an enrollee's template. Significant changes in an individual's eye shall require re-enrollment.
  - e. Scan acceptance tolerance or template match criteria shall be under system manager/operator control. Iris scanner shall determine when multiple attempts are needed to verify the iris being scanned and shall automatically prompt the enrollee for additional attempts up to three. Three failed attempts shall generate an entry-control alarm.
  - f. Average Verification Time: Iris scanner shall respond to passage requests by generating an entry request signal to the Controller. The verification time shall be 1.5 seconds or less from the moment iris scanner initiates the scan process until iris scanner generates a response signal.
  - g. Modes: Iris scanner shall provide an enrollment mode, a recognition mode, and a code/credential verification mode.
    - 1) In the enrollment mode, iris scanner shall create an iris template for new personnel and enter the template into system database file created for that person. Template information shall be compatible with system application software.
    - 2) In the recognition mode, iris scanner shall allow passage when the iris scan data from the verification attempt match an iris template stored in database files.
    - 3) In the code/credential verification mode, iris scanner shall allow passage when the iris scan data from the verification attempt match the iris scan template associated with the identification code entered into a keypad, or they match the iris scan template associated with credential card data read by a card reader.
  - h. Reports: Iris imaging shall create and store template match scores for all transactions involving iris scans. Template match scores shall be stored in the matching personnel data file used for report generation.
  - i. Power: Iris scanner shall be powered from its associated Controller, requiring not more than 45 W.
  - j. Enclosure: Eye scanners shall be available with enclosures that are suitable for surface, semiflush, or pedestal mounting. Mounting types shall additionally be suitable for installation in the following locations:
    - 1) Indoors, controlled environment.



- 2) Indoors, uncontrolled environment.
- k. Display: LED or other type of visual indicator display shall provide visual and audible status indications and user prompts. Indicate power on/off, and whether user passage requests have been accepted or rejected.

N. Enrollment Center

1. Equipment for enrolling personnel into, and removing personnel from, system database, using a dedicated workstation PC **OR** central-station equipment, **as directed**.
  - a. Include equipment to enroll selected biometric credentials.
2. Enrollment equipment shall support encoding of credential cards including cryptographic and other internal security checks as required for system.
  - a. Allow only authorized entry-control enrollment personnel to access the enrollment equipment using passwords.
  - b. Include enrollment subsystem configuration controls and electronic diagnostic aids for subsystem setup and troubleshooting with the Central Station.
  - c. Enrollment station records printer shall meet requirements of the report printer.
3. Entry-Control Enrollment Software:
  - a. Shall include database management functions for the system, and shall allow an operator to change and modify the data entered in the system as needed.
  - b. Software shall not have alarm response or acknowledgment functions as a programmable function.
  - c. Multiple, password-protected access levels shall be provided at the enrollment station.
  - d. Database management and modification functions shall require a higher operator-access level than personnel enrollment functions.
  - e. Software shall provide a means for disabling the enrollment station when it is unattended, to prevent unauthorized use.
  - f. Software shall provide a method to enter personnel identifying information into the entry-control database files through enrollment stations to include a credential unit in use at the installation.
  - g. In the case of personnel identity-verification subsystems, this data shall include biometric data.
  - h. Software shall allow entry of this data into the system database files through the use of simple menu selections and data fields. The data field names shall be customized to suit user and site needs.
  - i. Personnel identity-verification subsystems selected for use with the system shall fully support the enrollment function and shall be compatible with the entry-control database files.
4. Accessories:
  - a. Steel desk-type console, swivel chair on casters, and equipment racks.
  - b. Console and Equipment Racks: Comply with EIA-310-D.
  - c. Equipment, with the exception of the printers, shall be rack mounted in the console and equipment racks.
  - d. Storage Cabinet: Locking cabinet approximately 72 inches (1830 mm) high, 36 inches (915 mm) wide, and 24 inches (610 mm) deep, with 3 adjustable shelves and 2 storage racks for storage of disks, tapes, printouts, printer paper, ribbons, manuals, and other documentation.
5. System Capacity: Number of badges shall be limited only by hard disk space. Badge templates and images shall be in color, supporting the maximum color capability of Microsoft Windows operating system.
6. Badge Configuration:
  - a. Software for badge template creation shall include a template consisting of background and predetermined locations of photographs, text objects and data fields for text, and bar-code and biometric information. Include automatic sizing of data fields placed on a badge to compensate for names, which may otherwise be too large to fit in the area designated.
  - b. Allow different badge templates to be used for each department, tenant, or visitor.



- c. As a setup option, templates shall be automatically selected for the badge, based on the group the credential holder is assigned to. Allow the operator to override the automatic template selection and use a template chosen by the operator for creating a badge.
- d. Setup shall determine which graphics and credential holder information will be displayed and where on the card it will be placed. All data in the security access system such as name, code, group, access level, and any of the 99 user-defined fields shall be selectable, with the ability to place them anywhere on the card.
- e. System shall include an importing, filing, and recall system of stored images and shapes that can be placed on the badge.
- f. Allow multiple images on same badge, including, but not be limited to, bar codes, digital photos, and signatures.
- g. Support transparent backgrounds so that image is only surrounded by the intended background, but not its immediate background.
- 7. Photo Imaging: Integral to security access.
  - a. Import images from bitmap file formats, digital cameras, TWAIN cameras, or scanners. Allow image cropping and editing, WYSIWYG badge building application, and badge print preview and printing capabilities.
  - b. System shall support multiple images stored for each credential holder, including signatures, portrait views, and profile views.
- 8. Text Objects: Badge configuration shall provide for creation of custom text as an object, allowing font selection, typing, scaling, and formatting of the text object. Formatting options shall include changing font, font size, text flow, and text alignment; bending or curving the text object into a circle or semicircle; applying 3-D effects; and applying predefined effects such as tilt, extrusion, or beveling. Text shall be placed and optionally automatically centered within any region of the badge layout.
- 9. Badges and Credential Cards:
  - a. Badges are credential cards that do not contain data to be read by card readers.
  - b. Credential cards shall store uniquely coded data used by card readers as an Identifier.
    - 1) Magnetic-Stripe Cards: Comply with ISO 7810, ISO 7811-1, ISO 7811-2, ISO 7811-3, and ISO 7811-6. Use single-layer magnetic tape material that is coated with a plastic slick protective coat and affixed to the back of the credential card near the top.
    - 2) Wiegand Wire Effect Cards: Ferromagnetic wires laminated into the credential card using binary digits specified for Wiegand readers to generate a unique credential card identification code.
    - 3) Proximity Cards **OR** Key Fobs, **as directed**: Use proximity detection without physical contact with the proximity reader for proper operation.
  - c. Allow entry-control card to be modified by lamination or direct print process during the enrollment process for use as a picture and identification badge without reduction of readability. The design shall allow for the addition of at least one slot or hole to accommodate the attachment of a clip for affixing the credential card to the type of badge holder used at the site.
    - 1) Card Size and Dimensional Stability: Standard size, **2-1/8 by 3-3/8 inches (54 by 85 mm)**; dimensionally stable so that an undamaged card with deformations resulting from normal use is readable by the card reader.
    - 2) Card Material: Abrasion resistant, nonflammable, and nontoxic; and impervious to solar radiation and effects of ultraviolet light.
    - 3) Card Construction: Core and laminate or monolithic construction. Lettering, logos, and other markings shall be hot stamped into the credential material or direct printed.
      - a) With holographic images **OR** phosphorous ink, **as directed**, as a security enhancement.
      - b) Furnish equipment for on-site assembly and lamination of credential cards.
    - 4) Card Durability and Maintainability: Designed and constructed to yield a useful lifetime of at least 5 years or 5000 insertions or swipes, whichever results in a longer





period of time. Allow credential cards to be cleaned by wiping with a sponge or cloth wetted with soap and water.

10. Card-Making Equipment: Consisting of a workstation, video camera, video-imaging equipment, and a printer.
  - a. Camera: NTSC color standard, RGB video output, 470 lines minimum horizontal resolution, and automatic white balance with full rated output under illumination of 0.5 fc (5 lx).
  - b. Video Imaging: Live-image capture software and hardware and a digital signature capture pad.
  - c. Standard workstation, modified as follows:
    - 1) Redundant workstation is not required.
    - 2) Printer is not required.
    - 3) UPS is not required.
    - 4) Sound card is not required.
  - d. Printer: Dye-sublimation resin thermal transfer, 300 dpi resolution, 16.7 million colors, accepting cards ranging in size from 2.1 by 3 inches to 2.6 by 3.7 inches (53 by 76 mm to 66 by 94 mm) and having card thickness ranging from 0.020 to 0.060 inch (0.5 to 1.5 mm). Printer shall have options for encoding magnetic stripe using tracks 1, 2, and 3. Throughput shall be not less than 60 seconds per card.

O. Push-Button Switches

1. Push-Button Switches: Momentary-contact back-lighted push buttons, with stainless-steel switch enclosures.
  - a. Electrical Ratings:
    - 1) Minimum continuous current rating of 10 A at 120 V ac or 5 A at 240-V ac.
    - 2) Contacts that will make 720 VA at 60 A and that will break at 720 VA at 10 A.
  - b. Enclosures: Flush or surface mounting. Push buttons shall be suitable for flush mounting in the switch enclosures.
  - c. Enclosures shall additionally be suitable for installation in the following locations:
    - 1) Indoors, controlled environment.
    - 2) Indoors, uncontrolled environment.
    - 3) Outdoors.
  - d. Power: Push-button switches shall be powered from their associated Controller, using dc control.

P. Door And Gate Hardware Interface

1. Exit Device with Alarm: Operation of the exit device shall generate an alarm and annunciate a local alarm. Exit device and alarm contacts are specified in Division 08 Section "Door Hardware".
2. Exit Alarm: Operation of a monitored door shall generate an alarm. Exit devices and alarm contacts are specified in Division 08 Section "Door Hardware".
3. Electric Door Strikes: Use end-of-line resistors to provide power line supervision. Signal switches shall transmit data to Controller to indicate when the bolt is not engaged and the strike mechanism is unlocked, and shall report a forced entry. Power and signal shall be from the Controller. Electric strikes are specified in Division 08 Section "Door Hardware".
4. Electromagnetic Locks: End-of-line resistors shall provide power line supervision. Lock status sensing signal shall positively indicate door is secure. Power and signal shall be from the Controller. Electromagnetic locks are specified in Division 08 Section "Door Hardware".
5. Vehicle Gate Operator: Interface electrical operation of gate with controls of this Section. Vehicle gate operators shall be connected, monitored, and controlled, by the security access Controllers. Vehicle gate and accessories are specified in Division 32 Section "Chain Link Fences And Gates".

Q. Field-Processing Software

1. Operating System:

- a. Local processors shall contain an operating system that controls and schedules that local processor's activities in real time.
  - b. Local processor shall maintain a point database in its memory that includes parameters, constraints, and the latest value or status of all points connected to that local processor.
  - c. Execution of local processor application programs shall utilize the data in memory resident files.
  - d. Operating system shall include a real-time clock function that maintains the seconds, minutes, hours, date, and month, including day of the week.
  - e. Local processor real-time clock shall be automatically synchronized with the central station at least once per day to plus or minus 10 seconds (the time synchronization shall be accomplished automatically, without operator action and without requiring system shutdown).
2. Startup Software:
- a. Causes automatic commencement of operation without human intervention, including startup of all connected I/O functions.
  - b. Local processor restart program based on detection of power failure at the local processor shall be included in the local processor software.
  - c. Initiates operation of self-test diagnostic routines.
  - d. Upon failure of the local processor, if the database and application software are no longer resident, the local processor shall not restart and systems shall remain in the failure mode indicated until the necessary repairs are made.
  - e. If the database and application programs are resident, the local processor shall immediately resume operation.
3. Operating Mode:
- a. Local processors shall control and monitor inputs and outputs as specified, independent of communications with the central station or designated workstations.
  - b. Alarms, status changes, and other data shall be transmitted to the central station or designated workstations when communications circuits are operable.
  - c. If communications are not available, each local processor shall function in a stand-alone mode and operational data, including the status and alarm data normally transmitted to the central station or designated workstations, shall be stored for later transmission to the central station or designated workstations.
  - d. Storage for the latest 4000 events shall be provided at local processors, as a minimum.
  - e. Local processors shall accept software downloaded from the central station.
  - f. Panel shall support flash ROM technology to accomplish firmware downloads from a central location.
4. Failure Mode: Upon failure for any reason, each local processor shall perform an orderly shutdown and force all local processor outputs to a predetermined (failure-mode) state, consistent with the failure modes shown and the associated control device.
5. Functions:
- a. Monitoring of inputs.
  - b. Control of outputs.
  - c. Reporting of alarms automatically to the central station.
  - d. Reporting of sensor and output status to central station upon request.
  - e. Maintenance of real time, automatically updated by the central station at least once a day.
  - f. Communication with the central station.
  - g. Execution of local processor resident programs.
  - h. Diagnostics.
  - i. Download and upload data to and from the central station.

R. Field-Processing Hardware

1. Alarm Annunciation Local Processor:

- a. Respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.



- b. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
- c. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
- d. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
- e. Local processor shall report line supervision alarms to the central station.
- f. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 milliseconds.
- g. Alarm condition shall be transmitted to the central computer during the next interrogation cycle.
- h. Local processor outputs shall reflect the state of commands issued by the central station.
- i. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
- j. Local processor shall have at least four command outputs.
- k. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.
- 2. Processor Power Supply:
  - a. Local processor and sensors shall be powered from an uninterruptible power source.
  - b. Uninterruptible power source shall provide eight hours of battery back-up power in the event of primary power failure and shall automatically fully recharge the batteries within 12 hours after primary power is restored.
  - c. If the facility is without an emergency generator, the uninterruptible power source shall provide 24 hours of battery backup power.
  - d. There shall be no equipment malfunctions or perturbations or loss of data during the switch from primary to battery power and vice versa.
  - e. Batteries shall be sealed, non-outgassing type.
  - f. Power supply shall be equipped with an indicator for ac input power and an indicator for dc output power.
  - g. Loss of primary power shall be reported to the central station as an alarm.
- 3. Auxiliary Equipment Power: A GFI service outlet shall be furnished inside the local processor's enclosure.
- 4. Entry-Control Local Processor:
  - a. Entry-control local processor shall respond to interrogations from the field device network, recognize and store alarm status inputs until they are transmitted to the central station, and change outputs based on commands received from the central station.
  - b. Local processor shall also automatically restore communication within 10 seconds after an interruption with the field device network and provide dc line supervision on each of its alarm inputs.
  - c. Entry-control local processor shall provide local entry-control functions including communicating with field devices such as card readers, keypads, biometric personnel identity-verification devices, door strikes, magnetic latches, gate and door operators, and exit push buttons.
  - d. Processor shall also accept data from entry-control field devices as well as database downloads and updates from the central station that include enrollment and privilege information.
  - e. Processor shall send indications of successful or failed attempts to use entry-control field devices and shall make comparisons of presented information with stored identification information.
  - f. Processor shall grant or deny entry by sending control signals to portal-control devices and mask intrusion-alarm annunciation from sensors stimulated by authorized entries.

- g. Entry-control local processor shall use inputs from entry-control devices to change modes between access and secure.
- h. Local processor shall maintain a date-time- and location-stamped record of each transaction and transmit transaction records to the central station.
- i. Processor shall operate as a stand-alone portal controller using the downloaded database during periods of communication loss between the local processor and the central station.
- j. Processor shall store a minimum of 4000 transactions during periods of communication loss between the local processor and the central station for subsequent upload to the central station upon restoration of communication.
- k. Local processor inputs shall monitor dry contacts for changes of state that reflect alarm conditions.
- l. Local processor shall have at least eight alarm inputs which allow wiring contacts as normally open or normally closed for alarm conditions; and shall also provide line supervision for each input by monitoring each input for abnormal open, grounded, or shorted conditions using dc current change measurements.
- m. Local processor shall report line supervision alarms to the central station.
- n. Alarms shall be reported for any condition that remains abnormal at an input for longer than 500 ms.
- o. Alarm condition shall be transmitted to the central station during the next interrogation cycle.
- p. Entry-control local processor shall include the necessary software drivers to communicate with entry-control field devices. Information generated by the entry-control field devices shall be accepted by the local processor and automatically processed to determine valid identification of the individual present at the portal.
- q. Upon authentication of the credentials or information presented, the local processor shall automatically check privileges of the identified individual, allowing only those actions granted as privileges.
- r. Privileges shall include, but are not limited to, time of day control, day of week control, group control, and visitor escort control. The local processor shall maintain a date-time- and location-stamped record of each transaction.
- s. Transaction is defined as any successful or unsuccessful attempt to gain access through a controlled portal by the presentation of credentials or other identifying information.
- t. Local processor outputs shall reflect the state of commands issued by the central station.
- u. Outputs shall be a form C contact and shall include normally open and normally closed contacts.
- v. Local processor shall have at least four addressable outputs.
- w. The entry-control local processor shall also provide control outputs to portal-control devices.
- x. Local processor shall be able to communicate with the central station via RS-485 or TCP/IP as a minimum.
- y. The system manufacturer shall provide strategies for downloading database information for panel configurations and cardholder data to minimize the required download time when using IP connectivity.

S. Tia 232-F Ascii Interface Specifications

- 1. ASCII interface shall allow TIA 232-F connections to be made between the control station operating as the host PC and any equipment that will accept TIA 232-F ASCII command strings, such as CCTV switches, intercoms, and paging systems.
  - a. Alarm inputs in system shall allow for individual programming to output up to four unique ASCII character strings through two different COM ports on the host PC.
  - b. Inputs shall have the ability to be defined to transmit a unique ASCII string for alarm and one for restore through one COM port, and a unique ASCII string for a nonalarm, abnormal condition and one for a normal condition through the same or different COM port.
  - c. Predefined ASCII character strings shall have the ability to be up to 420 characters long with full use of all the ASCII control characters, such as return or line feed. Character



- strings shall be defined in the system database and then assigned to the appropriate inputs.
- d. COM ports of the host PC used to interface with external equipment shall be defined in the setup portion of the software. COM port's baud rate, word length, stop bits, and parity shall be definable in the software to match that of the external equipment.
2. Pager-System Interface: Alarms shall be able to activate a pager system with customized message for each input alarm.
    - a. TIA 232-F output shall be capable of connection to a pager interface that can be used to call a paging system or service and send a signal to a portable pager. System shall allow an individual alphanumeric message per alarm input to be sent to the paging system. This interface shall support both numeric and alphanumeric pagers.
  3. Alarm-System Interface:
    - a. TIA 232-F output shall be capable of transmitting alarms from other monitoring and alarm systems to central-station automation software.
    - b. Alternatively, alarms that are received by this access-control system are to be transferred to the alarm automation system as if they were sent through a digital alarm receiver.
      - 1) System shall be able to transmit an individual message from any alarm input to a burglar-alarm automation monitoring system.
      - 2) System shall be able to append to each message a predefined set of character strings as a prefix and a suffix.
- T. Floor Select Elevator Control
1. Elevator access control shall be integral to security access.
    - a. System shall be capable of providing full elevator security and control through dedicated Controllers without relying on the control-station host PC for elevator control decisions.
    - b. Access-control system shall enable and disable car calls on each floor and floor select buttons in each elevator car, restricting passengers' access to the floors where they have been given access.
    - c. System setup shall, through programming, automatically secure and unsecure each floor select button of a car individually by time and day. Each floor select button within a car shall be separately controlled so that some floors may be secure while others remain unsecure.
    - d. When a floor select button is secure, it shall require the passenger to use his/her access code and have access to that floor before the floor select button will operate. The passenger's credential shall determine which car call and floor select buttons are to be enabled, restricting access to floors unless authorized by system's access code database. Floor select button shall be enabled only in the car where the credential holder is the passenger.
  2. Security access system shall record which call button is pressed, along with credential and time information.
    - a. System Controller shall record elevator access data.
    - b. The Controller shall reset all additional call buttons that may have been enabled by the user's credential.
    - c. The floor select elevator control shall allow for manual override either individually by floor or by cab as a group from a workstation PC.
- U. Real-Time Guard Tour
1. Guard tour module shall provide the ability to plan, track, and route tours. Module shall input an alarm during tour if guard fails to make a station. Tours can be programmed for sequential or random tour-station order.
    - a. Guard tour setup shall define specific routes or tours for the guard to take, with time restrictions in which to reach every predefined tour station.
    - b. Guard tour activity shall be automatically logged to the central-station PC's hard drive.
    - c. If the guard is early or late to a tour station, a unique alarm per station shall appear at the Central Station to indicate the time and station.

- d. Guard tour setup shall allow the tours to be executed sequentially or in a random order with an overall time limit set for the entire tour instead of individual times for each tour station.
      - e. Setup shall allow recording of predefined responses that will display for the operator at the control station should a "Failed to Check-in" alarm occur.
    2. Guard tour module shall allow proprietary direct-connected systems to use security access-control hardware to perform guard tour management in real time.
    3. A tour station is a physical location a guard shall reach and perform an action indicating that the guard has arrived. This action, performed at the tour station, shall be 1 of 13 different events with any combination of station types within the same tour. A tour station shall be one of the following event types:
      - a. Access Granted.
      - b. Access Denied Code.
      - c. Access Denied Card plus PIN.
      - d. Access Denied Time Zone.
      - e. Access Denied Level.
      - f. Access Denied Facility.
      - g. Access Denied Code Timer.
      - h. Access Denied Anti-Passback.
      - i. Access Granted Passback Violation.
      - j. Alarm.
      - k. Restored.
      - l. Input Normal.
      - m. Input Abnormal.
    4. Guard tour and other system features shall operate simultaneously with no interference.
    5. Guard Tour Module Capacity: 999 possible guard tour definitions with each tour having up to 99 tour stations. System shall allow all 999 tours to be running at same time.
  - V. Video And Camera Control
    1. Control station or designated workstation displays live video from a CCTV source.
      - a. Control Buttons: On the display window, with separate control buttons to represent Left, Right, Up, Down, Zoom In, Zoom Out, Scan, and a minimum of two custom command auxiliary controls.
      - b. Provide at least seven icons to represent different types of cameras, with ability to import custom icons. Provide option for display of icons on graphic maps to represent their physical location.
      - c. Provide the alarm-handling window with a command button that will display the camera associated with the alarm point.
    2. Display mouse-selectable icons representing each camera source, to select source to be displayed. For CCTV sources that are connected to a video switcher, control station shall automatically send control commands through a COM port to display the requested camera when the camera icon is selected.
    3. Allow cameras with preset positioning to be defined by displaying a different icon for each of the presets. Provide control with Next and Previous buttons to allow operator to cycle quickly through the preset positions.
  - W. Cables
    1. General Cable Requirements: Comply with requirements in Division 28 Section "Conductors And Cables For Electronic Safety And Security" and as recommended by system manufacturer for integration requirement.
    2. PVC-Jacketed, TIA 232-F Cables:
      - a. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; PVC jacket.
      - b. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.



- c. NFPA 70, Type CM.
  - d. Flame Resistance: UL 1581 vertical tray.
3. Plenum-Type, TIA 232-F Cables:
  - a. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, and individual aluminum-foil/polyester-tape shielded pairs with 100 percent shield coverage; plastic jacket.
  - b. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
  - c. NFPA 70, Type CMP.
  - d. Flame Resistance: NFPA 262 flame test.
4. PVC-Jacketed, TIA 485-A Cables: Two pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, PVC insulation, unshielded, PVC jacket, and NFPA 70, Type CMG.
5. Plenum-Type, TIA 485-A Cables:
  - a. Two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and fluorinated-ethylene-propylene jacket.
  - b. NFPA 70, Type CMP.
  - c. Flame Resistance: NFPA 262 flame test.
6. Multiconductor, PVC Readers and Wiegand Keypads Cables:
  - a. No. 22 AWG, paired and twisted multiple conductors, stranded (7x30) tinned copper conductors, semirigid PVC insulation, overall aluminum foil-polyester tape shield with 100 percent shield coverage, plus tinned copper braid shield with 65 percent shield coverage, and PVC jacket.
  - b. NFPA 70, Type CMG.
  - c. Flame Resistance: UL 1581 Vertical Tray.
  - d. For TIA 232-F applications.
7. Paired PVC Readers and Wiegand Keypad Cables:
  - a. Three pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, individual aluminum foil-polyester tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
  - b. NFPA 70, Type CM.
  - c. Flame Resistance: UL 1581 Vertical Tray.
8. Paired PVC Readers and Wiegand Keypads Cable:
  - a. Three 3 pairs, twisted, No. 20 AWG, stranded (7x28) tinned copper conductors, polyethylene (polyolefin) insulation, individual aluminum foil-polyester tape shielded pairs each with No. 22 AWG, stranded (19x34) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
  - b. NFPA 70, Type CM.
  - c. Flame Resistance: UL 1581 Vertical Tray.
9. Paired, Plenum-Type, Reader and Wiegand Keypad Cable:
  - a. Three pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, individual aluminum foil-polypropylene tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
  - b. NFPA 70, Type CMP.
  - c. Flame Resistance: NFPA 262 Flame Test.
10. Multiconductor, Plenum-Type, Reader and Wiegand Keypad Cable:
  - a. Six conductors, No. 20 AWG, stranded (7x28) tinned copper conductors, fluorinated-ethylene-propylene insulation, overall aluminum foil-polyester tape shield with 100 percent shield coverage plus tinned copper braid shield with 85 percent shield coverage, and fluorinated-ethylene-propylene jacket.
  - b. NFPA 70, Type CMP.
  - c. Flame Resistance: NFPA 262 Flame Test.
11. Paired Lock Cable:

- a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
- b. NFPA 70, Type CMG.
- c. Flame Resistance: UL 1581 Vertical Tray.
- 12. Paired, Plenum-Type, Lock Cable:
  - a. One pair, twisted, No. 16 AWG, stranded (19x29) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
  - b. NFPA 70, Type CMP.
  - c. Flame Resistance: NFPA 262 Flame Test.
- 13. Paired Lock Cable:
  - a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
  - b. NFPA 70, Type CMG.
  - c. Flame Resistance: UL 1581 Vertical Tray.
- 14. Paired, Plenum-Type, Lock Cable:
  - a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
  - b. NFPA 70, Type CMP.
  - c. Flame Resistance: NFPA 262 Flame Test.
- 15. Paired Input Cable:
  - a. One pair, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, polypropylene insulation, overall aluminum foil-polyester tape shield with No. 22 AWG, stranded (7x30) tinned copper drain wire, 100 percent shield coverage, and PVC jacket.
  - b. NFPA 70, Type CMR.
  - c. Flame Resistance: UL 1666 Riser Flame Test.
- 16. Paired, Plenum-Type, Input Cable:
  - a. One pair, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, aluminum foil-polyester tape shield (foil side out), with No. 22 AWG drain wire, 100 percent shield coverage, and plastic jacket.
  - b. NFPA 70, Type CMP.
  - c. Flame Resistance: NFPA 262 Flame Test.
- 17. Paired AC Transformer Cable:
  - a. One pair, twisted, No. 18 AWG, stranded (7x26) tinned copper conductors, PVC insulation, unshielded, and PVC jacket.
  - b. NFPA 70, Type CMG.
- 18. Paired, Plenum-Type, AC Transformer Cable:
  - a. One pair, twisted, No. 18 AWG, stranded (19x30) tinned copper conductors, fluorinated-ethylene-propylene insulation, unshielded, and plastic jacket.
  - b. NFPA 70, Type CMP.
  - c. Flame Resistance: NFPA 262 Flame Test.
- 19. Elevator Travel Cable:
  - a. Steel center core, with shielded, twisted pairs, No. 20 AWG conductor size.
  - b. Steel center support shall be preformed, flexible, low-torsion, zinc-coated, steel wire rope; insulated with 60 deg C flame-resistant PVC and covered with a nylon or cotton braid.
  - c. Shielded Pairs: Insulated copper conductors; color-coded, insulated with 60 deg C flame-resistant PVC; each pair shielded with bare copper braid for 85 percent coverage.
  - d. Electrical grade, dry jute filler
  - e. Helically wound synthetic fiber binder
  - f. Rayon or cotton braid applied with 95 percent coverage.
  - g. 60 deg C PVC jacket specifically compounded for flexibility and abrasion resistance and complying with UL VW-1 and CSA FT1 flame rated.
- 20. LAN Cabling:
  - a. Comply with requirements in Division 28 Section "Conductors And Cables For Electronic Safety And Security".
  - b. NFPA 262.





- X. Transformers: NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.
- Y. Cable And Asset Management Software
  - 1. Computer-based cable and asset management system, with fully integrated database and graphic capabilities, complying with requirements in TIA/EIA-606.
    - a. Document physical characteristics by recording the network, asset, user, TIA/EAI details, device configurations, and exact connections between equipment and cabling.
      - 1) Manage the physical layer of security system.
      - 2) List device configurations.
      - 3) List and display circuit connections.
      - 4) Record firestopping data.
      - 5) Record grounding and bonding connections and test data.
    - b. Information shall be presented in database view, schematic plans, or technical drawings.
      - 1) Microsoft Visio Technical Drawing shall be used as drawing and schematic plans software. Drawing symbols, system layout, and design shall comply with SIA/IAPSC AG-01.
    - c. System shall interface with the following testing and recording devices:
      - 1) Direct upload tests from circuit testing instrument into the PC.
      - 2) Direct download circuit labeling into labeling printer.
  - 2. Software shall be designed for Microsoft Windows of same version as security access system's Central Station and workstations and shall be installed on the designated PC, using a hard drive dedicated only to this management function. Hard-drive capacity shall be not less than 50 GB.

### 1.3 EXECUTION

- A. Examination
  - 1. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
  - 2. Examine roughing-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
  - 3. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Preparation
  - 1. Comply with recommendations in SIA CP-01.
  - 2. Comply with TIA/EIA 606-A, "Administration Standard for Commercial Telecommunications Infrastructure."
  - 3. Obtain detailed Project planning forms from manufacturer of access-control system; develop custom forms to suit Project. Fill in all data available from Project plans and specifications and publish as Project planning documents for review and approval.
    - a. Record setup data for control station and workstations.
    - b. For each Location, record setup of controller features and access requirements.
    - c. Propose start and stop times for time zones and holidays, and match up access levels for doors.
    - d. Set up groups, facility codes, linking, and list inputs and outputs for each controller.
    - e. Assign action message names and compose messages.
    - f. Set up alarms. Establish interlocks between alarms, intruder detection, and video surveillance features.
    - g. Prepare and install alarm graphic maps.
    - h. Develop user-defined fields.
    - i. Develop screen layout formats.
    - j. Propose setups for guard tours and key control.

- k. Discuss badge layout options; design badges.
  - l. Complete system diagnostics and operation verification.
  - m. Prepare a specific plan for system testing, startup, and demonstration.
  - n. Develop acceptance test concept and, on approval, develop specifics of the test.
  - 4. Develop cable and asset-management system details; input data from construction documents. Include system schematics and Visio Technical Drawings in electronic format.
  - 5. In meetings with the Owner, present Project planning documents and review, adjust, and prepare final setup documents. Use final documents to set up system software.
- C. Cabling
- 1. Comply with NECA 1, "Good Workmanship in Electrical Contracting."
  - 2. Install cables and wiring according to requirements in Division 28 Section "Conductors And Cables For Electronic Safety And Security".
  - 3. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
  - 4. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental air spaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
  - 5. Install LAN cables using techniques, practices, and methods that are consistent with Category 5E rating of components and fiber-optic rating of components, and that ensure Category 6 performance and fiber-optic performance of completed and linked signal paths, end to end.
  - 6. Boxes and enclosures containing security system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered to be accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
  - 7. Install end-of-line resistors at the field device location and not at the Controller or panel location.
- D. Cable Application
- 1. Comply with TIA-569-B, "Commercial Building Standard for Telecommunications Pathways and Spaces."
  - 2. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
  - 3. TIA 232-F Cabling: Install at a maximum distance of 50 feet (15 m).
  - 4. TIA 485-A Cabling: Install at a maximum distance of 4000 feet (1220 m).
  - 5. Card Readers and Keypads:
    - a. Install number of conductor pairs recommended by manufacturer for the functions specified.
    - b. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from Controller to the reader is 250 feet (75 m), and install No. 20 AWG wire if maximum distance is 500 feet (150 m).
    - c. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the Controller.
    - d. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
  - 6. Install minimum No. 16 AWG cable from Controller to electrically powered locks. Do not exceed 250 feet (75 m) OR 500 feet (150 m), as directed.
  - 7. Install minimum No. 18 AWG ac power wire from transformer to Controller, with a maximum distance of 25 feet (8 m).
- E. Grounding
- 1. Comply with Division 26 Section "Grounding And Bonding For Electrical Systems".
  - 2. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."



3. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
  4. Bond shields and drain conductors to ground at only one point in each circuit.
  5. Signal Ground:
    - a. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
    - b. Bus: Mount on wall of main equipment room with standoff insulators.
    - c. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.
- F. Installation
1. Push Buttons: Where multiple push buttons are housed within a single switch enclosure, they shall be stacked vertically with each push-button switch labeled with ~~1/4-inch~~ (6.4-mm) high text and symbols as required. Push-button switches shall be connected to the Controller associated with the portal to which they are applied, and shall operate the appropriate electric strike, electric bolt, or other facility release device.
  2. Install card readers, keypads, push buttons, and biometric readers.
- G. Identification
1. In addition to requirements in this Article, comply with applicable requirements in Division 26 Section "Identification For Electrical Systems" and with TIA/EIA-606.
  2. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
  3. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
    - a. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
    - b. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.
  4. At completion, cable and asset management software shall reflect as-built conditions.
- H. System Software and Hardware
1. Develop, install, and test software and hardware, and perform database test for the complete and proper operation of systems involved. Assign software license to the Owner.
- I. Field Quality Control
1. Perform tests and inspections.
    - a. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist testing.
  2. Testing and Inspections:
    - a. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use Class 2, bidirectional, Category 5 tester. Test for faulty connectors, splices, and terminations. Test according to TIA/EIA-568-B.1, "Commercial Building Telecommunications Cabling Standards - Part 1 General Requirements." Link performance for UTP cables must comply with minimum criteria in TIA/EIA-568-B.
    - b. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery

- operating time. Provide special equipment and software if testing requires special or dedicated equipment.
- c. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
  3. Devices and circuits will be considered defective if they do not pass tests and inspections.
  4. Prepare test and inspection reports.
- J. Startup Service
1. Engage a factory-authorized service representative to supervise and assist with startup service.
    - a. Complete installation and startup checks according to approved procedures that were developed in "Preparation" Article and with manufacturer's written instructions.
    - b. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.
- K. Protection
1. Maintain strict security during the installation of equipment and software. Rooms housing the control station, and workstations that have been powered up shall be locked and secured, with an activated burglar alarm and access-control system reporting to a Central Station complying with UL 1610, "Central-Station Burglar-Alarm Units," during periods when a qualified operator in the employ of Contractor is not present.

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Task	Specification	Specification Description
28 16 11 00	27 51 43 00	Educational Intercommunications and Program Systems
28 16 11 00	26 33 43 00b	Public Address and Mass Notification Systems

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## SECTION 28 21 31 00 - VIDEO SURVEILLANCE

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for video surveillance. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes a video surveillance system consisting of cameras, digital video recorder, data transmission wiring, and a control station with its associated equipment.
2. Video surveillance system shall be integrated with monitoring and control system specified in Division 13 Section "Perimeter Security", "Intrusion Detection", "Security Access", and PLC Electronic Detention Monitoring and Control Systems", which specifies systems integration.

#### C. Definitions

1. AGC: Automatic gain control.
2. BNC: Bayonet Neill-Concelman - type of connector.
3. B/W: Black and white.
4. CCD: Charge-coupled device.
5. FTP: File transfer protocol.
6. IP: Internet protocol.
7. LAN: Local area network.
8. MPEG: Moving picture experts group.
9. NTSC: National Television System Committee.
10. PC: Personal computer.
11. PTZ: Pan-tilt-zoom.
12. RAID: Redundant array of independent disks.
13. TCP: Transmission control protocol - connects hosts on the Internet.
14. UPS: Uninterruptible power supply.
15. WAN: Wide area network.

#### D. Performance Requirements

1. Seismic Performance: Video surveillance system shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

#### E. Submittals

1. Product Data: For each type of product indicated. Include dimensions and data on features, performance, electrical characteristics, ratings, and finishes.
2. Shop Drawings: For video surveillance. Include plans, elevations, sections, details, and attachments to other work.
  - a. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
  - b. Functional Block Diagram: Show single-line interconnections between components for signal transmission and control. Show cable types and sizes.
  - c. Dimensioned plan and elevations of equipment racks, control panels, and consoles. Show access and workspace requirements.
  - d. UPS: Sizing calculations.
  - e. Wiring Diagrams: For power, signal, and control wiring.





3. Equipment List: Include every piece of equipment by model number, manufacturer, serial number, location, and date of original installation. Add pretesting record of each piece of equipment, listing name of person testing, date of test, set points of adjustments, name and description of the view of preset positions, description of alarms, and description of unit output responses to an alarm.
4. Seismic Qualification Certificates: For video surveillance, cameras, camera-supporting equipment, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
  - d. Field quality-control reports.
  - e. Operation and Maintenance Data: For cameras, power supplies, infrared illuminators, monitors, videotape recorders, digital video recorders, video switches, and control-station components to include in emergency, operation, and maintenance manuals. Include the following:
    - 1) Lists of spare parts and replacement components recommended to be stored at the site for ready access.
5. Warranty: Sample of special warranty.

#### F. Quality Assurance

1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Comply with NECA 1.
3. Comply with NFPA 70.
4. Electronic data exchange between video surveillance system with an access-control system shall comply with SIA TVAC.

#### G. Project Conditions

1. Environmental Conditions: Capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
  - a. Control Station: Rated for continuous operation in ambient temperatures of **60 to 85 deg F (16 to 29 deg C)** and a relative humidity of 20 to 80 percent, noncondensing.
  - b. Interior, Controlled Environment: System components, except central-station control unit, installed in air-conditioned **OR** temperature-controlled, **as directed**, interior environments shall be rated for continuous operation in ambient temperatures of **36 to 122 deg F (2 to 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 1 enclosures.
  - c. Interior, Uncontrolled Environment: System components installed in non-air-conditioned **OR** non-temperature-controlled, **as directed**, interior environments shall be rated for continuous operation in ambient temperatures of **0 to 122 deg F (minus 18 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, noncondensing. Use NEMA 250, Type 3R **OR** Type 4 **OR** Type 12 **OR** Type 12K, **as directed**, enclosures.
  - d. Exterior Environment: System components installed in locations exposed to weather shall be rated for continuous operation in ambient temperatures of **minus 30 to plus 122 deg F (minus 34 to plus 50 deg C)** dry bulb and 20 to 90 percent relative humidity, condensing. Rate for continuous operation when exposed to rain as specified in NEMA 250, winds up to **85 mph (137 km/h)** and snow cover up to **24 inches (610 mm)** thick, **as directed**. Use NEMA 250, Type 3 **OR** Type 3R **OR** Type 3S **OR** Type 4 **OR** Type 4X, **as directed**, enclosures.
  - e. Hazardous Environment: System components located in areas where fire or explosion hazards may exist because of flammable gases or vapors, flammable liquids, combustible dust, or ignitable fibers shall be rated, listed, and installed according to NFPA 70.

- f. Corrosive Environment: System components subject to corrosive fumes, vapors, and wind-driven salt spray in coastal zones. Use NEMA 250, Type 4X **OR** Type 6P, **as directed**, enclosures.
- g. Security Environment: Camera housing for use in high-risk areas where surveillance equipment may be subject to physical violence.

H. Warranty

- 1. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of cameras, equipment related to camera operation, and control-station equipment that fail in materials or workmanship within specified warranty period.
  - a. Warranty Period: Three years from date of Final Completion.

1.2 PRODUCTS

A. System Requirements

- 1. Video-signal format shall comply with NTSC standard, composite interlaced video. Composite video-signal termination shall be 75 ohms.
- 2. Surge Protection: Protect components from voltage surges originating external to equipment housing and entering through power, communication, signal, control, or sensing leads. Include surge protection for external wiring of each conductor's entry connection to components.
  - a. Minimum Protection for Power Connections 120 V and More: Auxiliary panel suppressors complying with requirements in Division 16 Section "Transient Voltage Suppression."
  - b. Minimum Protection for Communication, Signal, Control, and Low-Voltage Power Connections: Comply with requirements in Division 16 Section "Transient Voltage Suppression" as recommended by manufacturer for type of line being protected.
- 3. Tamper Protection: Tamper switches on enclosures, control units, pull boxes, junction boxes, cabinets, and other system components shall initiate a tamper-alarm signal when unit is opened or partially disassembled. Control-station, control-unit alarm display shall identify tamper alarms and indicate locations.

B. Standard Cameras

- 1. B/W Camera:
  - a. Comply with UL 639.
  - b. Pickup Device: CCD interline transfer, 252,000 512(H) by 492(V) pixels, **unless directed otherwise**.
  - c. Horizontal Resolution: 380 lines.
  - d. Signal-to-Noise Ratio: Not less than 46 dB.
  - e. With AGC, manually selectable on or off.
  - f. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination, as directed by the Owner, with camera AGC off, **as directed**.

**OR**

Sensitivity: Camera shall deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test shall be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.

  - g. Manually selectable modes for backlight compensation or normal lighting.
  - h. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
  - i. Motion Detector: Built-in digital.
- 2. Color Camera:
  - a. Comply with UL 639.
  - b. Pickup Device: CCD interline transfer, 380,000 771(H) by 492(V) pixels, **unless directed otherwise**.
  - c. Horizontal Resolution: 480 lines.
  - d. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.



- e. With AGC, manually selectable on or off.
  - f. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination, as directed by the Owner, with camera AGC off, **as directed.**  
**OR**  
Sensitivity: Camera shall deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test shall be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
  - g. Manually selectable modes for backlight compensation or normal lighting.
  - h. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
  - i. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
  - j. Motion Detector: Built-in digital.
3. Automatic Color Dome Camera: Assembled and tested as a manufactured unit, containing dome assembly, color camera, motorized pan and tilt, zoom lens, and receiver/driver.
- a. Comply with UL 639.
  - b. Pickup Device: CCD interline transfer, 380,000 768(H) by 494(V) pixels, **unless directed otherwise.**
  - c. Horizontal Resolution: 480 lines.
  - d. Signal-to-Noise Ratio: Not less than 50 dB, with camera AGC off.
  - e. With AGC, manually selectable on or off.
  - f. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination, as directed by the Owner, with camera AGC off, **as directed.**  
**OR**  
Sensitivity: Camera shall deliver 1-V peak-to-peak video signal at the minimum specified light level. Illumination for the test shall be with lamps rated at approximately 2200-K color temperature, and with camera AGC off.
  - g. Manually selectable modes for backlight compensation or normal lighting.
  - h. Pan and Tilt: Direct-drive motor, 360-degree rotation angle, and 180-degree tilt angle. Pan-and-tilt speed shall be controlled by operator. Movement from preset positions shall be not less than 300 degrees per second.
  - i. Preset Positioning: Eight user-definable scenes, each allowing 16-character titles. Controls shall include the following:
    - 1) In "sequence mode," camera shall continuously sequence through preset positions, with dwell time and sequencing under operator control.
    - 2) Motion detection shall be available at each camera position.
    - 3) Up to four preset positions may be selected to be activated by an alarm. Each of the alarm positions may be programmed to output a response signal.
  - j. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
  - k. White Balance: Auto-tracing white balance, with manually settable fixed balance option.
  - l. Motion Detector: Built-in digital.
  - m. Dome shall support multiplexed control communications using coaxial cable recommended by manufacturer.

#### C. Submersible Cameras

- 1. Camera: Color, designed for underwater monitoring and for inspecting pipes and storm drains. Attributes as follows:
  - a. Infrared LEDs to provide illumination in zero-light conditions.
  - b. **60-foot (18.3-m)** factory-installed cable with BNC connector for video and a 2.1-mm jack for 12-V dc power supply.
  - c. An adjustable swivel mount and attachment base.
  - d. Pickup Device: CCD interline transfer, 290,000 500(H) by 580(V) pixels, **unless directed otherwise.**

- e. Horizontal Resolution: 380 lines.
  - f. Signal-to-Noise Ratio: Not less than 50 dB.
  - g. With AGC, from 4 to 39 dB.
  - h. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination of 0.1 lux at f/2.0.
  - i. Scanning Synchronization: Internal.
  - j. White Balance: Auto-tracing white balance, for colors ranging from 2800 to 8200 deg K.
- D. Reinforced Dome Cameras
- 1. Camera: Designed for high-abuse locations, with a weathertight semirecessed **OR** surface, **as directed**, mounting, impact-resistance polycarbonate dome, and heavy-gage, 6061 T6 aluminum body.
    - a. Suitable for exterior environment, rated for continuous operation in ambient temperatures of **minus 40 to plus 122 deg F (minus 40 to plus 50 deg C)** dry bulb and up to 85 percent relative humidity.
    - b. Pickup Device: CCD interline transfer, 290,000 510(H) by 492(V) pixels, **unless directed otherwise**.
    - c. Horizontal Resolution: 350 lines.
    - d. Signal-to-Noise Ratio: Not less than 46 dB.
    - e. With AGC and automatic backlight compensation.
    - f. Sensitivity: Camera shall provide usable images in low-light conditions, delivering an image at a scene illumination of 6 lux at f/2.0.
    - g. Scanning Synchronization: Determined by external synch over the coaxial cable. Camera shall revert to internally generated synchronization on loss of external synch signal.
    - h. White Balance: Auto-tracing white balance.
- E. Lenses
- 1. Description: Optical-quality coated lens, designed specifically for video-surveillance applications and matched to specified camera. Provide color-corrected lenses with color cameras.
    - a. Auto-Iris Lens: Electrically controlled iris with circuit set to maintain a constant video level in varying lighting conditions.
    - b. Fixed Lens: With calibrated focus ring.
    - c. Zoom Lens: Motorized, remote-controlled unit, rated as "quiet operating." Features include the following:
      - 1) Electrical Leads: Filtered to minimize video signal interference.
      - 2) Motor Speed: Variable.
      - 3) Lens shall be available with preset positioning capability to recall the position of specific scenes.
- F. Power Supplies
- 1. Low-voltage power supplies matched for voltage and current requirements of cameras and accessories, and of type as recommended by manufacturer of camera, infrared illuminator, **as directed**, and lens.
    - a. Enclosure: NEMA 250, Type 1 **OR** Type 3 **OR** Type 4X, **as directed**.
- G. Infrared Illuminators
- 1. Description: Lighting fixtures that emit light only in the infrared spectrum, suitable for use with cameras indicated, for nighttime surveillance, without emitting visible light.
    - a. Field-Selectable Beam Patterns: Narrow, medium, and wide.
    - b. Rated Lamp Life: More than 8000 hours.
    - c. Power Supply: 12-V ac/dc **OR** 120-V ac, **as directed**.
  - 2. Area Coverage: Illumination to **150 feet (50 m)** in a narrow beam pattern.
  - 3. Exterior housings shall be suitable for same environmental conditions as the associated camera.
- H. Camera-Supporting Equipment



1. Minimum Load Rating: Rated for load in excess of the total weight supported times a minimum safety factor of two.
2. Pan Units: Motorized automatic-scanning units arranged to provide remote-controlled manual and automatic camera panning action, and equipped with matching mounting brackets.
  - a. Scanning Operation: Silent, smooth, and positive.
  - b. Stops: Adjustable without disassembly, to limit the scanning arc.
3. Pan-and-Tilt Units: Motorized units arranged to provide remote-controlled aiming of cameras with smooth and silent operation, and equipped with matching mounting brackets.
  - a. Panning Rotation: 0 to 355 degrees, with adjustable stops.
  - b. Tilt Movement: 90 degrees, plus or minus 5 degrees, with adjustable stops.
  - c. Speed: 12 degrees per second in both horizontal and vertical planes.
  - d. Wiring: Factory prewired for camera and zoom lens functions and pan-and-tilt power and control.
  - e. Built-in encoders or potentiometers for position feedback, and thermostat-controlled heater, **as directed**.
  - f. Pan-and-tilt unit shall be available with preset positioning capability to recall the position of a specific scene.
4. Mounting Brackets for Fixed Cameras: Type matched to items supported and mounting conditions. Include manual pan-and-tilt adjustment.
5. Protective Housings for Fixed and Movable Cameras: Steel or 6061 T6 aluminum, **as directed**, enclosures with internal camera mounting and connecting provisions that are matched to camera/lens combination and mounting and installing arrangement of camera to be housed.
  - a. Tamper switch on access cover sounds an alarm signal when unit is opened or partially disassembled. Central-control unit shall identify tamper alarms and indicate location in alarm display. Tamper switches and central-control unit are specified in Division 13 Section "Intrusion Detection."
  - b. Camera Viewing Window: Polycarbonate **OR** Lexan, **as directed**, window, aligned with camera lens.
  - c. Duplex Receptacle: Internally mounted.
  - d. Alignment Provisions: Camera mounting shall provide for field aiming of camera and permit removal and reinstallation of camera lens without disturbing camera alignment.
  - e. Built-in, thermostat-activated heater and blower units. Units shall be automatically controlled so the environmental limits of the camera equipment are not exceeded.
  - f. Sun shield shall not interfere with normal airflow around the housing.
  - g. Mounting bracket and hardware for wall or ceiling mounting of the housing. Bracket shall be of same material as the housing; mounting hardware shall be stainless steel.
  - h. Finish: Housing and mounting bracket shall be factory finished using manufacturer's standard finishing process suitable for the environment.
  - i. Enclosure Rating: as directed by the Owner.

#### I. Monitors

1. Monochrome:
  - a. Metal cabinet units designed for continuous operation.
  - b. Screen Size (Diagonal Dimension): as directed by the Owner.
  - c. Horizontal Resolution: 600 lines, minimum, at center.
  - d. Minimum Front Panel Devices and Controls: Power switch; power-on indicator; and brightness, horizontal-hold, vertical-hold, and contrast controls.
  - e. Mounting: Adjustable tilting and training.
  - f. Mounting: Single, 14-inch (356-mm) **OR** Dual, 9-inch (229-mm), **as directed**, vertical, EIA 19-inch (483-mm) electronic equipment rack or cabinet complying with CEA 310-E.
  - g. Electrical: 120-V ac, 60 Hz.
2. Color:
  - a. Metal cabinet units designed for continuous operation.
  - b. Screen Size (Diagonal Dimension): as directed by the Owner.
  - c. Horizontal Resolution: 300 lines.

- d. Minimum Front Panel Devices and Controls: Power switch; power-on indicator; and brightness, contrast, color, and tint controls.
- e. Degaussing: Automatic.
- f. Mounting: Single, 14-inch (356-mm) OR Dual, 9-inch (229-mm), as directed, vertical, EIA 19-inch (483-mm) electronic equipment rack or cabinet complying with CEA 310-E.
- g. Electrical: 120-V ac, 60 Hz.

J. Videotape Recorders

- 1. Description: Industrial, time-lapse type recorder, designed for continuous operation. Tape format is 1/2 inch (13 mm) using industrial-grade, T-120 cassettes.
  - a. Horizontal Resolution: 400 lines, minimum.
  - b. Recording Heads: Rotary-scan type.
  - c. Integral Timer: Permits programming of recording operation for adjustable daily and weekly periods.
  - d. Time-Lapse Operating Modes: Multiple, covering 24 to 240 hours, minimum.
  - e. Other Operating Modes:
    - 1) Manual play and recording at two- and six-hour speeds.
    - 2) Forward and reverse high-speed search.
    - 3) Reverse, slow, and single-frame play.
  - f. Alarm Recording: Operating mode is automatically switched from time-lapse to two- or six-hour recording mode when an externally generated alarm signal is received.
  - g. Audio Recording: 70 to 7000 Hz. Phono and microphone input; phono output.
  - h. Time and Date Generator: Records time and date legend in corner of recorded scenes.
  - i. Tape Counter: Displays tape position.
  - j. Manual Recording Lock: Key or keypad operated. Prevents unauthorized tampering or control changes during preset operation.
  - k. Signal-to-Noise Ratio: 45 dB for video output in standard play mode.
  - l. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E, or freestanding desktop.

K. Digital Video Recorders

- 1. Description: Digital, time-lapse type, full-frame and motion recorder, with removable hard drive.
  - a. Recording Time: 400 hours minimum.
  - b. Resolution: 720 by 480 lines, minimum.
  - c. Programming shall be from trackball and push buttons on face of the recorder, settings shall be displayed on any video monitor connected to the recorder. Programming shall include the following:
    - 1) Motion analysis graph.
    - 2) Password protection.
    - 3) Alarm and timer controls.
    - 4) Continuous recording option.
    - 5) Time-lapse operating modes.
    - 6) Search video by time, event, or motion.
  - d. Programming: SmartMedia card for software updating, image archiving, and image transfer to a PC.
  - e. Storage: 80-GB, unless directed otherwise, removable hard drive. Software shall permit hot-swapping drives.
  - f. Compression: MPEG-2.
  - g. Time and Date Generator: Records time (hr:min:sec) and date legend of each frame.
  - h. Audio Recording: 70 to 7000 Hz. Phono and microphone input; phono output.
  - i. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E, or freestanding desktop.

L. Network Video Recorders

- 1. External storage or internal 250-1, 500-GB hard disk drive.
  - a. Video and audio recording over TCP/IP network.





- b. Video recording of MPEG-2 and MPEG-4 streams.
- c. Video recording up to 48 Mbps for internal storage and up to 100 Mbps for external storage.
- d. Duplex Operation: Simultaneous recording and playback.
- e. Continuous and alarm-based recording.
- f. Full-Featured Search Capabilities: Search based on camera, time, or date.
- g. Automatic data replenishment to ensure recording even if network is down.
- h. Digital certification by watermarking.
- i. Internal RAID storage or non-RAID storage of up to 1500 GB.
- j. Capable of adding external RAID storage up to 7000 GB for models with no internal storage.
- k. Full integration with LAN, Intranet, or Internet through standard Web browser or video management software.
- l. Integrated Web server FTP server functionality.
- m. Supports up to 16, 32, or 64 devices.

M. Digital Switchers

- 1. Quad Switch: For displaying images from four cameras on a single monitor. Provide color switcher if one or more cameras or monitors are in color.
  - a. Controls: Unit-mounted front panel.
  - b. Resolution: 720 by 480 lines, **unless directed otherwise**.
  - c. Modes: Auto, manual, and alarm. In manual mode, each channel can also be viewed in single display mode. In the event of an alarm, alarming channel shall automatically switch to full screen. If several alarms are activated, channels in alarm shall be in auto-switching mode.
  - d. Channel Loss Alarm: Audible buzzer; occurrence details shall be recorded.
  - e. Time: Indicate date and time.
  - f. Timing of Auto-Switcher: 1 to 30 seconds, selectable.
  - g. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E, or freestanding desktop.
- 2. Manual Switch Bank: Low-loss, high-isolation, multiple-video switch to allow manual switching of multiple quad switches and cameras to a single output. Switches shall be illuminated.
- 3. Sequential Switchers: Automatically sequence outputs of multiple cameras to single monitor and videotape recorder.
  - a. Switching Time Interval: Continuously adjustable, 5 to 20 seconds minimum, with manual override.
  - b. Skip-Sequential-Hold Switch: One for each camera, with LED to indicate active camera.
  - c. Camera Identification Legend: Either on-screen message or label at skip-sequential switch.
  - d. Alarm Switching: In the event of an alarm, alarming channel shall automatically switch the monitor to full screen.
  - e. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.
- 4. PTZ Controls: Arranged for multiple-camera control, with switches to select camera to be controlled.
  - a. Pan-and-Tilt Control: Joystick type.
  - b. Zoom Control: Momentary-contact, "in-out" push button.
  - c. Automatic-Scan Control: A push button for each camera with pan capability that places camera in automatic-scanning mode.

N. IP Video Systems

- 1. Description:
  - a. System shall provide high-quality delivery and processing of IP-based video, audio, and control data using standard Ethernet-based networks.
  - b. System shall have seamless integration of all video surveillance and control functions.

- c. Graphical user interface software shall manage all IP-based video matrix switching and camera control functions, two-way audio communication, alarm monitoring and control, and recording and archive/retrieval management. IP system shall also be capable of integrating into larger system environments.
  - d. System design shall include all necessary compression software for high-performance, dual-stream, MPEG-2/MPEG-4 video. Unit shall provide connections for all video cameras, camera PTZ control data, bidirectional audio, discreet sensor inputs, and control system outputs.
  - e. All camera signals shall be compressed, encoded, and delivered onto the network for processing and control by the IP video-management software.
  - f. Camera system units shall be ruggedly built and designed for extreme adverse environments, complying with NEMA Type environmental standards.
  - g. Encoder/decoder combinations shall place video, audio, and data network stream that can be managed from multiple workstations on the user's LAN or WAN.
  - h. All system interconnect cables, workstation PCs, PTZ joysticks, and network intermediate devices shall be provided for full performance of specified system.
- O. Video Motion Sensors (Interior)
- 1. Device Performance: Detect changes in video signal within a user-defined protected zone. Video inputs shall be composite video as defined in SMPTE 170M. Provide an alarm output for each video input.
    - a. Detect movement within protected zone of intruders wearing clothing with a reflectivity that differs from that of background scene by a factor of two. Reject all other changes in video signal.
    - b. Modular design that allows for expansion or modification of number of inputs.
    - c. Controls:
      - 1) Size of detection zones.
      - 2) Sensitivity of detection of each protected zone.
    - d. Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.
- P. Control Stations
- 1. Description: Heavy-duty, freestanding, modular, metal furniture units arranged to house electronic equipment. Coordinate component arrangement and wiring with components and wiring of other systems.
  - 2. Equipment Mounting: Standard 19-inch (483-mm) rack complying with CEA 310-E.
  - 3. Normal System Power Supply: 120 V, 60 Hz, through a locked disconnect device and an isolation transformer in central-station control unit. Central-station control unit shall supply power to all components connected to it unless otherwise indicated.
  - 4. Power Continuity for Control Station: Batteries in power supplies of central-station control units and individual system components shall maintain continuous system operation during outages of both normal and backup ac system supply.
    - a. Batteries: Rechargeable, valve-regulated, recombinant, sealed, lead-acid type with nominal 10-year life expectancy. Capacity adequate to operate portions of system served including audible trouble signal devices for up to four hours and audible and visual alarm devices under alarm conditions for an additional 10 minutes.
    - b. Battery Charger: Solid-state, fully automatic, variable-charging-rate type. Charger shall recharge fully discharged battery within 24 hours.
  - 5. Annunciation: Indicate change in system condition and switching of system or component to backup power.
- Q. Signal Transmission Components
- 1. Cable: Coaxial cable elements have 75-ohm nominal impedance. Comply with requirements in Division 16 Section "Conductors and Cables for Electronic Safety and Security."
  - 2. Video Surveillance Coaxial Cable Connectors: BNC type, 75 ohms. Comply with requirements in Division 16 Section "Conductors and Cables for Electronic Safety and Security."





### 1.3 EXECUTION

#### A. Examination

1. Examine pathway elements intended for cables. Check raceways and other elements for compliance with space allocations, installation tolerance, hazards to camera installation, and other conditions affecting installation.
2. Examine roughing-in for LAN, WAN, and IP network before device installation.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Wiring

1. Comply with requirements in Division 16 Section "Raceways and Boxes."  
**OR**  
Wiring Method: Install cables in raceways unless otherwise indicated.
  - a. Except raceways are not required in accessible indoor ceiling spaces and attics.  
**OR**  
Except raceways are not required in hollow gypsum board partitions.
  - b. Conceal raceways and wiring except in unfinished spaces.
2. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
3. Splices, Taps, and Terminations: For power and control wiring, use numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
4. For LAN connection and fiber-optic and copper communication wiring, comply with Division 16 Sections "Communications Backbone Cabling" and "Communications Horizontal Cabling."
5. Grounding: Provide independent-signal circuit grounding recommended in writing by manufacturer.

#### C. Video Surveillance System Installation

1. Install cameras and infrared illuminators level and plumb.
2. Install cameras with ~~84-inch-~~ (2134-mm-) minimum clear space below cameras and their mountings. Change type of mounting to achieve required clearance.
3. Set pan unit and pan-and-tilt unit stops to suit final camera position and to obtain the field of view required for camera. Connect all controls and alarms, and adjust.
4. Install power supplies and other auxiliary components at control stations unless otherwise indicated.
5. Install tamper switches on components indicated to receive tamper switches, arranged to detect unauthorized entry into system-component enclosures and mounted in self-protected, inconspicuous positions.
6. Avoid ground loops by making ground connections only at the control station.
  - a. For 12- and 24-V dc cameras, connect the coaxial cable shields only at the monitor end.
7. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification."

#### D. Field Quality Control

1. Perform tests and inspections.
2. Tests and Inspections:
  - a. Inspection: Verify that units and controls are properly installed, connected, and labeled, and that interconnecting wires and terminals are identified.
  - b. Pretesting: Align and adjust system and pretest components, wiring, and functions to verify that they comply with specified requirements. Conduct tests at varying lighting levels, including day and night scenes as applicable. Prepare video-surveillance equipment for acceptance and operational testing as follows:
    - 1) Prepare equipment list described in "Submittals" Article.

- 2) Verify operation of auto-iris lenses.
- 3) Set back-focus of fixed focal length lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Adjust until image is in focus with and without the filter.
- 4) Set back-focus of zoom lenses. At focus set to infinity, simulate nighttime lighting conditions by using a dark glass filter of a density that produces a clear image. Additionally, set zoom to full wide angle and aim camera at an object **50 to 75 feet (17 to 23 m)** away. Adjust until image is in focus from full wide angle to full telephoto, with the filter in place.
- 5) Set and name all preset positions; consult Owner's personnel.
- 6) Set sensitivity of motion detection.
- 7) Connect and verify responses to alarms.
- 8) Verify operation of control-station equipment.
- c. Test Schedule: Schedule tests after pretesting has been successfully completed and system has been in normal functional operation for at least 14 days. Provide a minimum of 10 days' notice of test schedule.
- d. Operational Tests: Perform operational system tests to verify that system complies with Specifications. Include all modes of system operation. Test equipment for proper operation in all functional modes.
3. Video surveillance system will be considered defective if it does not pass tests and inspections.
4. Prepare test and inspection reports.
- E. Adjusting
  1. Occupancy Adjustments: When requested within 12 months of date of Final Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose. Tasks shall include, but are not limited to, the following:
    - a. Check cable connections.
    - b. Check proper operation of cameras and lenses. Verify operation of auto-iris lenses and adjust back-focus as needed.
    - c. Adjust all preset positions; consult Owner's personnel.
    - d. Recommend changes to cameras, lenses, and associated equipment to improve Owner's use of video surveillance system.
    - e. Provide a written report of adjustments and recommendations.
- F. Cleaning
  1. Clean installed items using methods and materials recommended in writing by manufacturer.
  2. Clean video-surveillance-system components, including camera-housing windows, lenses, and monitor screens.
- G. Demonstration
  1. Train Owner's maintenance personnel to adjust, operate, and maintain video-surveillance equipment.

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Task	Specification	Specification Description
28 21 31 00	28 16 11 00b	Security Access
28 42 11 00	22 12 23 26	Underground Storage Tanks

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## SECTION 28 46 00 00 - OIL/WATER SEPARATOR

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for oil/water separator. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Scope

1. The separator shall be designed for gravity separation of sand, grit, settleable solids, or semisolids, and free oils (hydrocarbons and other petroleum products) from wastewater. Separator shall be installed belowground with top access at or above grade level. The source of the influent to the separator shall be gravity flow from storm water runoff, hydrocarbon spills, and/or cleaning/maintenance operations.

#### C. Performance

##### 1. Influent Characteristics

- a. Provide separator designed for intermittent and variable flows of water, oil, or any combination of non-emulsified oil-water mixtures. Minimum separator retention time shall be 10 minutes. Operating temperatures of the influent oil in water mixture shall range from 40 degrees F. to 80 degrees F. The specific gravity of the oils at operating temperatures shall range from 0.71 to 0.92. The specific gravity of the fresh water at operating temperatures shall range from 1.00 to 1.03.

##### 2. Effluent Characteristics

- a. The free oil and grease concentration in the effluent from the separator shall not exceed 10 mg/l (10 PPM) to satisfy requirements of the NPDES stormwater discharge permit. To achieve this goal, it will be necessary to remove all free oil droplets equal to and greater than 20 microns.

#### D. Design Criteria

1. The separator shall be listed to Underwriters' Laboratories UL-SU2215. Construction and performance of the oil/water separators shall be in accordance with UL-SU2215. Provide certification documentation detailing criteria under which the system was tested. UL-SU2215 label shall be prominently displayed on manway covers.
2. Separator shall be designed in accordance with Stokes Law and the American Petroleum Institute Publication 421, "Monographs on Refinery Environmental Control - Management of Water Discharges; Design and Operation of Oil/Water Separators." Effective surface area calculations, signed and stamped by a Registered Professional Engineer shall be submitted to document specified effluent quality based on complete removal of the specified oil globule at design flow. A separator with lower effective surface area than required is not permissible.
3. Separator capacities, dimensions, construction, and thickness shall be in strict accordance with Underwriters' Laboratories, Subject UL-58 Standard for Safety, Steel Underground Tanks for Flammable and Combustible Liquids, September 30, 1997, Double Wall construction with 360 degree Steel Secondary Containment. The inner steel tank shall be completely contained within the outer steel tank, enclosing 100% of the tank volume. The tank shall have a double steel shell with a space between the layers. The space between the inner and outer steel walls shall be monitored with an approved electronic leak detection device through a pipe that extends vertically to the top of the tank from a small sump at the bottom. Tank construction using thin walled primary tank with external fiberglass jacket shall not be permissible.
4. Separator Corrosion Control System shall be in strict accordance with Underwriters' Laboratories Inc. Subject UL-1746 Standard for External Corrosion Protection Systems for Steel Underground Storage Tanks and the HighGuard® External Corrosion Protection Specifications.



5. Oil/water separator shall comply with National Fire Protection Association NFPA 30 Flammable and Combustible Liquids Code, 2003 Edition.
6. Separator vessel volume shall allow for a hydraulic retention time of ten (10) minutes to ensure laminar flow conditions which result in hydraulic uniformity and high effluent quality. Volume reduction will adversely affect separator performance by increasing horizontal velocity and turbulence, therefore a separator of smaller volume is not permissible.
7. Separator shall be the standard patented product of a steel tank manufacturer regularly engaged in the production of such equipment. Manufacturer shall have at least 20 years experience in manufacturing similar units for identical applications. No subcontracting of tank fabrication shall be permitted.
8. Separator shall be fabricated, inspected, and tested for leakage before shipment from the factory by manufacturer as a completely assembled vessel ready for installation.
9. Separator shall be cylindrical, horizontal, atmospheric-type steel vessel intended for the separation and storage of flammable and combustible liquids. The separator shall have the structural strength to withstand static and dynamic hydraulic loading while empty and during operating conditions. The Oil/Water Separator's dimensions and thickness shall be in strict compliance with Roark's Formulas for Stress and Strain as presented in UL 58, September 30, 1997. Calculations, signed and stamped by a Registered Professional Engineer shall be submitted to document structural strength under specified overbearing or external pressure. A separator with a reduced shell thickness is not permissible.
10. Separator shall have an oil storage capacity equal to about 43% of the total vessel volume and an emergency oil spill capacity equal to 80% of the total vessel volume.
11. To prevent extensive shutdown and maintenance, the separator design must allow solids to fall unhindered by turbulence, and oil droplets to rise without risk of re-emulsifying due to collisions with interfering solids. The use of plastic perforated tubes, spherical balls, or irregular shaped media will increase the facility's maintenance costs and shall not be permitted.
12. Separator shall consist of inlet and outlet connections, integral sand interceptor compartment, non-clogging flow distributor and energy dissipater device, stationary under flow baffle, presettling chamber for solids, sludge baffle, oil coalescing chamber with removable parallel flat/corrugated plate coalescer, with removable plates, and sectionalized removable polypropylene impingement coalescers to optimize separation of free oil from water, effluent downcomer positioned to prevent discharge of free oil that has been separated from the water, access ways for coalescers and each chamber, fittings for vent, oil pump-out, sampling, gauging, leak detection, and lifting lugs.

E. Submittals:

1. Shop Drawings: shop drawings for oil water separators shall show principal dimensions and location of all fittings.
2. Instructions: provide three complete sets of installation, operation, and maintenance instructions with separator.
3. Quality Control: Quality control, inspection procedures, and reports shall be considered part of the submittal package.

F. Warranty

1. The manufacturer shall warrant its products to be free from defects in material and workmanship for a period of one year from the date of shipment. The warranty shall be limited to repair or replacement of the defective part(s).
2. The manufacturer's warranty shall be standard limited warranty in effect at time of purchase.

## 1.2 PRODUCTS

A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

1. Highland Tank, One Highland Road, Box 338, Stoystown, PA 15563, Phone 814-893-5701, FAX 893-6126, E-mail [ows.info@highlandtank.com](mailto:ows.info@highlandtank.com), Website <http://www.highlandtank.com>

B. Product

1. Provide and install Highland Tank Model HTC Series "G" UL-SU2215 approved Belowground Double Wall Parallel Flat/Corrugated Plate Gravity Displacement Oil/Water Separator with Integral Sand Interceptor Compartment. Separator shall be furnished with oil level alarm and leak detection systems. Oil/Water Separator shall be of capacity to comply with Spill Prevention Control and Countermeasures (SPCC) plan requirements at the facility. The sizing of this oil/water separator is consistent with industry protocols for complying with the minimum federal spill and discharge regulations therefore a separator of smaller volume is not permissible.
2. Separator shall be furnished with a Corella™ inclined parallel flat/corrugated plate coalescer to simultaneously separate free oil droplets and settleable or suspended solids particles from water without clogging of the coalescer.

C. Description

1. Separator shall be standard prefabricated inclined parallel flat/corrugated plate, gravity displacement type unit.
2. Separator shall be cylindrical with capacities, dimensions, construction, and thickness in strict accordance with Underwriters' Laboratories Subject 58, Double Wall construction using flat-flanged heads. Separator shall comply with National Fire Protection Association NFPA 30 Flammable and Combustible Liquids Code, 2003 Edition.
3. The separator shall be a pre-packaged, pre-engineered, ready to install unit consisting of:
  - a. An influent connection, flanged. An internal influent nozzle at the inlet end of the separator. Nozzle discharge to be located at the furthest diagonal point from the effluent discharge opening.
  - b. An integral sand interceptor compartment containing one (1) manhole, UL approved, complete with extension, cover, gasket, and bolts. A heavy-duty bulkhead shall retain sand, grit, settleable solids or semisolids and prevent them from entering the separation chamber. Bulkhead shall have a transfer pipe.
  - c. A velocity head diffusion baffle at the inlet to:
    - 1) reduce horizontal velocity and flow turbulence.
    - 2) distribute the flow equally over the separator's cross sectional area.
    - 3) direct the flow in a serpentine path in order to enhance hydraulic characteristics and fully utilize all separator volume.
    - 4) completely isolate all inlet turbulence from the separation chamber.
  - d. A sediment chamber to disperse flow and collect oily solids and sediments.
  - e. A sludge baffle to retain settleable solids and sediment and prevent them from entering the separation chamber.
  - f. An Oil/Water Separation Chamber containing a removable Corella™ inclined parallel flat/corrugated plate coalescer. The coalescer shall have individual removable plates, sloped towards the sediment chamber. Each coalescing plate shall be flat on the top and corrugated on the bottom. The flat top plate shall resist clogging and clotting with solids. The corrugations of each of the plate bottoms shall be shaped and positioned to enhance collisions between the rising oil droplets and coalesce between them thereby improving separator efficiency. The coalescer shall:
    - 1) effect separation of oil and solids from all strata of the wastewater stream.
    - 2) shorten the vertical distance that an oil globule or solid particle has to rise or sink, respectively, for effective removal. Minimum plate gap to be 3/4".
    - 3) enhance coalescence and agglomeration by causing the smaller globules and particles (those possessing smaller rising/settling rates) to coalesce and collect on the plates thereby forming larger globules and particles that separate rapidly in water.
    - 4) direct the flow paths of the separated oil to the surface of the separator and separated solids to the bottom of the separator.
    - 5) allow solids to fall unhindered by turbulence, and oil droplets to rise without risk of re-emulsifying due to collisions with interfering solids.
  - g. The Oil/Water Separation Chamber shall also contain a sectionalized removable "Petro-Screen"™ polypropylene impingement coalescer designed to intercept oil globules of less





than 20 microns in diameter. Heavy, one-piece impingement coalescers are not permissible.

- h. An internal effluent downcomer at the outlet end of the separator, to allow for discharge from the bottom of the separation chamber only.
- i. An effluent connection, flanged.
- j. Fittings for vent, interface/level sensor, leak detection, waste oil pump-out, sampling, and gauge.
- k. Two (2) manholes, UL approved, complete with extension, cover, gasket, and bolts. One manway shall be placed between the inlet and the parallel flat/corrugated plate coalescer to facilitate access into sediment chamber for solids removal. One manway shall be placed between the parallel flat/corrugated plate coalescer and outlet to facilitate access into the oil water separation chamber for oil removal.
- l. Lifting lugs at balancing points for handling and installation.
- m. Identification plates: Plates shall be affixed in prominent location and be durable and legible throughout equipment life.
- n. HighGuard® Corrosion Protection System consisting of:
  - 1) Isolation Spool Pieces
  - 2) Dielectric Isolation Gaskets and Bushings
  - 3) External surfaces commercial grit blast, coated 75 mils DFT Self-Reinforcing Polyurethane.
- o. Internal surfaces commercial grit blast and coated with 10 mils DFT heavy duty Polyurethane.

D. Accessories

- 1. Separator shall be supplied with an audible and visual alarm system that indicates hi oil level (visual only) and hi hi oil level (audible and visual) of oil storage in the oil/water separator and an audible and visual leak detection alarm system that indicates hydrocarbon and/or water in the interstice. A silence control shall be provided for the audible alarms. Level sensor(s) shall be intrinsically safe. Level sensor floats shall be made of stainless steel. The control panel shall contain both level sensor and detection control. The control panel shall be NEMA 4. Power to the control panel shall be as directed by the Owner.
- 2. Separator shall be supplied with Polyester Hold-down straps.
- 3. Separator shall be supplied with prefabricated Concrete Deadman Anchors.
- 4. Separator shall be supplied with cylindrical and/or rectangular steel Grade Level Manways designed to AASHTO H20 requirements.

1.3 EXECUTION

A. Installation

- 1. Installation shall be in strict compliance with manufacturer's instructions and shall comply with all applicable local, state, and federal requirements.

END OF SECTION 28 46 00 00

## SECTION 28 46 21 17 - DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for digital, addressable fire alarm system. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Fire-alarm control unit.
  - b. Manual fire-alarm boxes.
  - c. System smoke detectors.
  - d. Nonsystem smoke detectors.
  - e. Heat detectors.
  - f. Notification appliances.
  - g. Firefighters' two-way telephone communication service.
  - h. Magnetic door holders.
  - i. Remote annunciator.
  - j. Addressable interface device.
  - k. Digital alarm communicator transmitter.
  - l. Radio alarm transmitter.
  - m. System printer.

#### C. Definitions

1. LED: Light-emitting diode.
2. NICET: National Institute for Certification in Engineering Technologies.

#### D. System Description

1. Noncoded, UL-certified **OR** FMG-placarded, **as directed**, addressable system, with multiplexed signal transmission, dedicated to fire-alarm service only.
2. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

#### E. Performance Requirements

1. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
  - a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event," **as directed**.

#### F. Submittals

1. General Submittal Requirements:
  - a. Submittals shall be approved by authorities having jurisdiction prior to submitting them to the Owner.
  - b. Shop Drawings shall be prepared by persons with the following qualifications:
    - 1) Trained and certified by manufacturer in fire-alarm system design.
    - 2) NICET-certified fire-alarm technician, Level III **OR** Level IV, **as directed**, minimum.
    - 3) Licensed or certified by authorities having jurisdiction.
2. Product Data: For each type of product indicated.
3. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.



- a. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
- b. Include voltage drop calculations for notification appliance circuits.
- c. Include battery-size calculations.
- d. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
- e. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.
- f. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
- g. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
4. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Drawings showing the location of each smoke and heat detector, ratings of each, and installation details as needed to comply with listing conditions of the detector.
  - b. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.
5. Qualification Data: For qualified Installer.
6. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.
  - a. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
  - b. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
  - c. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
7. Field quality-control reports.
8. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. Deliver copies to authorities having jurisdiction and include the following:
  - a. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
  - b. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
  - c. Record copy of site-specific software.
  - d. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
    - 1) Frequency of testing of installed components.
    - 2) Frequency of inspection of installed components.
    - 3) Requirements and recommendations related to results of maintenance.
    - 4) Manufacturer's user training manuals.
  - e. Manufacturer's required maintenance related to system warranty requirements.
  - f. Abbreviated operating instructions for mounting at fire-alarm control unit.
  - g. Copy of NFPA 25.
9. Software and Firmware Operational Documentation:
  - a. Software operating and upgrade manuals.
  - b. Program Software Backup: On magnetic media or compact disk, complete with data files.
  - c. Device address list.
  - d. Printout of software application and graphic screens.

G. Quality Assurance

1. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
2. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II **OR** Level III **OR** Level IV, **as directed**, technician.
3. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
5. NFPA Certification: Obtain certification according to NFPA 72 by an NRTL.
6. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.
7. NFPA Certification: Obtain certification according to NFPA 72 in the form of a placard by an FMG-approved alarm company.
8. NFPA Certification: Obtain certification according to NFPA 72 by agency having jurisdiction.

H. Project Conditions

1. Interruption of Existing Fire-Alarm Service: Do not interrupt fire-alarm service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed interruption of fire-alarm service.
  - b. Do not proceed with interruption of fire-alarm service without the Owner written permission.

I. Sequencing And Scheduling

1. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.
2. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

J. Software Service Agreement

1. Comply with UL 864.
2. Technical Support: Beginning with Final Completion, provide software support for two years.
3. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Final Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.
  - a. Provide 30 days' notice to the Owner to allow scheduling and access to system and to allow the Owner to upgrade computer equipment if necessary.

1.2 PRODUCTS

A. Systems Operational Description

1. Fire-alarm signal initiation shall be by one or more of the following devices and systems, **as directed**:
  - a. Manual stations.
  - b. Heat detectors.
  - c. Flame detectors.
  - d. Smoke detectors.
  - e. Duct smoke detectors.
  - f. Verified automatic alarm operation of smoke detectors.
  - g. Automatic sprinkler system water flow.
  - h. Heat detectors in elevator shaft and pit.



- i. Fire-extinguishing system operation.
- j. Fire standpipe system.
- 2. Fire-alarm signal shall initiate the following actions:
  - a. Continuously operate alarm notification appliances.
  - b. Identify alarm at fire-alarm control unit and remote annunciators, **as directed**.
  - c. Transmit an alarm signal to the remote alarm receiving station.
  - d. Unlock electric door locks in designated egress paths.
  - e. Release fire and smoke doors held open by magnetic door holders.
  - f. Activate voice/alarm communication system.
  - g. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
  - h. Activate smoke-control system (smoke management) at firefighter smoke-control system panel.
  - i. Activate stairwell and elevator-shaft pressurization systems.
  - j. Close smoke dampers in air ducts of designated air-conditioning duct systems.
  - k. Recall elevators to primary or alternate recall floors.
  - l. Activate emergency lighting control.
  - m. Activate emergency shutoffs for gas and fuel supplies.
  - n. Record events in the system memory.
  - o. Record events by the system printer.
- 3. Supervisory signal initiation shall be by one or more of the following devices and actions:
  - a. Valve supervisory switch.
  - b. Low-air-pressure switch of a dry-pipe sprinkler system.
  - c. Elevator shunt-trip supervision.
- 4. System trouble signal initiation shall be by one or more of the following devices and actions:
  - a. Open circuits, shorts, and grounds in designated circuits.
  - b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
  - c. Loss of primary power at fire-alarm control unit.
  - d. Ground or a single break in fire-alarm control unit internal circuits.
  - e. Abnormal ac voltage at fire-alarm control unit.
  - f. Break in standby battery circuitry.
  - g. Failure of battery charging.
  - h. Abnormal position of any switch at fire-alarm control unit or annunciator.
  - i. Fire-pump power failure, including a dead-phase or phase-reversal condition.
  - j. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.
- 5. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators, **as directed**. Record the event on system printer.

#### B. Fire-Alarm Control Unit

- 1. General Requirements for Fire-Alarm Control Unit:
  - a. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
    - 1) System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
    - 2) Include a real-time clock for time annotation of events on the event recorder and printer.
  - b. Addressable initiation devices that communicate device identity and status.
    - 1) Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit, **as directed**.
    - 2) Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
  - c. Addressable control circuits for operation of mechanical equipment.

2. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
  - a. Annunciator and Display: Liquid-crystal type, 1 **OR** 2 **OR** 3, **as directed**, line(s) of 40 **OR** 80, **as directed**, characters, minimum.
  - b. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters, **as directed**.
3. Circuits:
  - a. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
    - 1) Initiating Device Circuits: Style D **OR** Style E, **as directed**.
    - 2) Notification Appliance Circuits: Style Z.
    - 3) Signaling Line Circuits: Style 2 **OR** Style 5 **OR** Style 6 **OR** Style 7, **as directed**.
    - 4) Install no more than 50 addressable devices on each signaling line circuit.
  - b. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class B.
    - 1) Initiating Device Circuits: Style A **OR** Style B **OR** Style C, **as directed**.
    - 2) Notification Appliance Circuits: Style W **OR** Style X **OR** Style Y, **as directed**.
    - 3) Signaling Line Circuits: Style 0.5 **OR** Style 1 **OR** Style 3 **OR** Style 3.5 **OR** Style 4 **OR** Style 4.5, **as directed**.
    - 4) Install no more than 50 addressable devices on each signaling line circuit.
  - c. Serial Interfaces: Two RS-232 ports for printers.
4. Stairwell Pressurization: Provide an output signal using an addressable relay to start the stairwell pressurization system. Signal shall remain on until alarm conditions are cleared and fire-alarm system is reset. Signal shall not stop in response to alarm acknowledge or signal silence commands.
  - a. Pressurization starts when any alarm is received at fire-alarm control unit.
  - b. Alarm signals from smoke detectors at pressurization air supplies have a higher priority than other alarm signals that start the system.
5. Smoke-Alarm Verification:
  - a. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
  - b. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
  - c. Record events by the system printer.
  - d. Sound general alarm if the alarm is verified.
  - e. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
6. Notification Appliance Circuit: Operation shall sound in a <Insert pattern>.
7. Elevator Recall:
  - a. Smoke detectors at the following locations shall initiate automatic elevator recall. Alarm-initiating devices, except those listed, shall not start elevator recall, **as directed**.
    - 1) Elevator lobby detectors except the lobby detector on the designated floor.
    - 2) Smoke detector in elevator machine room.
    - 3) Smoke detectors in elevator hoistway.
  - b. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
  - c. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.
    - 1) Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.
8. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be **OR** not be, **as directed**, connected to fire-alarm system.
9. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-



adjustment schedule changes in system memory, and print out the final adjusted values on system printer.

10. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
11. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in a separate cabinet located in the fire command center **OR** as a special module that is part of fire-alarm control unit, **as directed**.
  - a. Indicated number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711 and be listed by an NRTL.
    - 1) Allow the application of and evacuation signal to indicated number of zones and, at same time, allow voice paging to the other zones selectively or in any combination.
    - 2) Programmable tone and message sequence selection.
    - 3) Standard digitally recorded messages for "Evacuation" and "All Clear."
    - 4) Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification appliance circuits of fire-alarm control unit.
  - b. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
  - c. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
12. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.
13. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals **OR** supervisory and digital alarm communicator transmitters **OR** digital alarm radio transmitters, **as directed**, shall be powered by 24-V dc source.
  - a. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
14. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
  - a. Batteries: Sealed lead calcium **OR** Sealed, valve-regulated, recombinant lead acid **OR** Vented, wet-cell pocket, plate nickel cadmium, **as directed**.
15. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

#### C. Manual Fire-Alarm Boxes

1. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
  - a. Single-action mechanism, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
  - b. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.

- c. Station Reset: Key- or wrench-operated switch.
  - d. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
  - e. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.
- D. System Smoke Detectors
- 1. General Requirements for System Smoke Detectors:
    - a. Comply with UL 268; operating at 24-V dc, nominal.
    - b. Detectors shall be four **OR** two, **as directed**, -wire type.
    - c. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
    - d. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
    - e. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
    - f. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.
    - g. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
      - 1) Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for **15 or 20 deg F (8 or 11 deg C)** per minute.
      - 2) Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at **135 or 155 deg F (57 or 68 deg C)**.
      - 3) Provide multiple levels of detection sensitivity for each sensor.
  - 2. Photoelectric Smoke Detectors:
    - a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
    - b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      - 1) Primary status.
      - 2) Device type.
      - 3) Present average value.
      - 4) Present sensitivity selected.
      - 5) Sensor range (normal, dirty, etc.).
  - 3. Ionization Smoke Detector:
    - a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
    - b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      - 1) Primary status.
      - 2) Device type.
      - 3) Present average value.
      - 4) Present sensitivity selected.
      - 5) Sensor range (normal, dirty, etc.).
  - 4. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
    - a. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
    - b. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
      - 1) Primary status.
      - 2) Device type.
      - 3) Present average value.





- 4) Present sensitivity selected.
- 5) Sensor range (normal, dirty, etc.).
- c. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
- d. Each sensor shall have multiple levels of detection sensitivity.
- e. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
- f. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

#### E. Nonsystem Smoke Detectors

##### 1. Single-Station Smoke Detectors:

- a. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device, **as directed**.
- b. Auxiliary Relays: One Form C rated at 0.5 A **OR** Form A and one Form C, both rated at 0.5 A, **as directed**.
- c. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.
- d. Visible Notification Appliance: 177-cd strobe.
- e. Heat sensor, 135 deg F (57 deg C) combination rate-of-rise, **as directed**, and fixed temperature.
- f. Test Switch: Push to test; simulates smoke at rated obscuration.
- g. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
- h. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
- i. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
- j. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.

##### 2. Single-Station Duct Smoke Detectors:

- a. Comply with UL 268A; operating at 120-V ac.
- b. Sensor: LED or infrared light source with matching silicon-cell receiver.
  - 1) Detector Sensitivity: Smoke obscuration between 2.5 and 3.5 percent/foot (0.008 and 0.011 percent/mm) when tested according to UL 268A.
- c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
  - 1) Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
- d. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
- e. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

#### F. Heat Detectors

- 1. General Requirements for Heat Detectors: Comply with UL 521.
- 2. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
  - a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
  - b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

3. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of **190 deg F (88 deg C)**.
    - a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
    - b. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
  4. Continuous Linear Heat-Detector System:
    - a. Detector Cable: Rated detection temperature **155 deg F (68 deg C)**. NRTL listed for "regular" service and a standard environment. Cable includes two steel actuator wires twisted together with spring pressure, wrapped with protective tape, and finished with PVC outer sheath. Each actuator wire is insulated with heat-sensitive material that reacts with heat to allow the cable twist pressure to short-circuit wires at the location of elevated temperature.
    - b. Control Unit: Two-zone or multizone unit as indicated. Provide same system power supply, supervision, and alarm features as specified for fire-alarm control unit.
    - c. Signals to Fire-Alarm Control Unit: Any type of local system trouble shall be reported to fire-alarm control unit as a composite "trouble" signal. Alarms on each detection zone shall be individually reported to central fire-alarm control unit as separately identified zones.
    - d. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- G. Notification Appliances
1. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections.
  2. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
    - a. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
  3. Chimes, Low-Level Output: Vibrating type, 75-dBA minimum rated output.
  4. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
  5. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured **10 feet (3 m)** from the horn, using the coded signal prescribed in UL 464 test protocol.
  6. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum **1-inch (25-mm)** high letters on the lens.
    - a. Rated Light Output:
      - 1) **15 OR 30 OR 75 OR 110 OR 177, as directed, cd.**  
**OR**  
15/30/75/110 cd, selectable in the field.
    - b. Mounting: Wall mounted unless otherwise indicated.
    - c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
    - d. Flashing shall be in a temporal pattern, synchronized with other units.
    - e. Strobe Leads: Factory connected to screw terminals.
    - f. Mounting Faceplate: Factory finished, red **OR** white, **as directed**.
  7. Voice/Tone Notification Appliances:
    - a. Appliances shall comply with UL 1480 and shall be listed and labeled by an NRTL.
    - b. High-Range Units: Rated 2 to 15 W.
    - c. Low-Range Units: Rated 1 to 2 W.
    - d. Mounting: Flush **OR** Semirecessed **OR** Surface mounted and bidirectional, **as directed**.



- e. Matching Transformers: Tap range matched to acoustical environment of speaker location.
- H. Firefighters' Two-Way Telephone Communication Service
  - 1. Dedicated, two-way, supervised, telephone voice communication links between fire-alarm control unit, the fire command center, **as directed**, and remote firefighters' telephone stations. Supervised telephone lines shall be connected to talk circuits by controls in a control module. Provide the following:
    - a. Common-talk type for firefighter use only.
    - b. Selective-talk type for use by firefighters and fire wardens.
    - c. Controls to disconnect phones from talk circuits if too many phones are in use simultaneously.
    - d. Audible Pulse and Tone Generator, and High-Intensity Lamp: When a remote telephone is activated, it causes audible signal to sound and high-intensity lamp to flash.
    - e. Selector panel controls shall provide for simultaneous operation of up to six telephones in selected zones. Indicate ground faults and open or shorted telephone lines on the panel front by individual LEDs.
    - f. Display: Graphic **OR** Liquid-crystal digital, **as directed**, to indicate location of caller.
    - g. Remote Telephone Cabinet: Flush- or surface-mounted cabinet as indicated, factory-standard red finish, with handset.
      - 1) Install one-piece handset to cabinet with vandal-resistant armored cord. Silk-screened or engraved label on cabinet door, designating "Fire Warden Phone" **OR** "Fire Emergency Phone", **as directed**.
      - 2) With "break-glass" type door access lock.
    - h. Remote Telephone Jack Stations: Single-gang, stainless-steel-plate mounted plug, engraved "Fire Warden Phone" **OR** "Fire Emergency Phone", **as directed**.
    - i. Handsets: **<Insert number>** push-to-talk-type sets with noise-canceling microphone, **as directed**, stored in a cabinet adjacent to fire-alarm control unit **OR** in the fire command center, **as directed**.
- I. Magnetic Door Holders
  - 1. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
    - a. Electromagnet: Requires no more than 3 W to develop **25-lbf (111-N)** holding force.
    - b. Wall-Mounted Units: Flush mounted unless otherwise indicated.
    - c. Rating: 24-V ac or dc.
    - d. Rating: 120-V ac.
  - 2. Material and Finish: Match door hardware.
- J. Remote Annunciator
  - 1. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
    - a. Mounting: Flush **OR** Surface, **as directed**, cabinet, NEMA 250, Type 1.
  - 2. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.
- K. Addressable Interface Device
  - 1. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.
  - 2. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall **OR** to circuit-breaker shunt trip for power shutdown, **as directed**.
- L. Digital Alarm Communicator Transmitter

1. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.
2. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one **OR** two, **as directed**, telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either, **as directed**, line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
3. Local functions and display at the digital alarm communicator transmitter shall include the following:
  - a. Verification that both telephone lines are available.
  - b. Programming device.
  - c. LED display.
  - d. Manual test report function and manual transmission clear indication.
  - e. Communications failure with the central station or fire-alarm control unit.
4. Digital data transmission shall include the following:
  - a. Address of the alarm-initiating device.
  - b. Address **OR** Zone, **as directed**, of the supervisory signal.
  - c. Address **OR** Zone, **as directed**, of the trouble-initiating device.
  - d. Loss of ac supply or loss of power.
  - e. Low battery.
  - f. Abnormal test signal.
  - g. Communication bus failure.
5. Secondary Power: Integral rechargeable battery and automatic charger.
6. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

M. Radio Alarm Transmitter

1. Transmitter shall comply with NFPA 1221 and shall be listed and labeled by an NRTL.
2. Comply with 47 CFR 90.
3. Description: Manufacturer's standard commercial product; factory assembled, wired, tested, and ready for installation and operation.
  - a. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
  - b. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by the Owner.
  - c. Normal Power Input: 120-V ac.
  - d. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
  - e. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand **100 mph (160 km/h)**, **as directed**, with a gust factor of 1.3 without failure.
  - f. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
  - g. Antenna-Cable Connectors: Weatherproof.
  - h. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.
4. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-



reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:

- a. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
- b. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
- c. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
- d. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
- e. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
- f. Local Fire-Alarm-System Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm, **as directed**.

N. System Printer

1. Printer shall be listed and labeled by an NRTL as an integral part of fire-alarm system.

O. Device Guards

1. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
  - a. Factory fabricated and furnished by manufacturer of device.
  - b. Finish: Paint of color to match the protected device.

### 1.3 EXECUTION

A. Equipment Installation

1. Comply with NFPA 72 for installation of fire-alarm equipment.
2. Equipment Mounting: Install fire-alarm control unit on concrete base with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-place Concrete".
  - a. Install seismic bracing. Comply with requirements in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
  - b. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on **18-inch (450-mm)** centers around the full perimeter of concrete base.
  - c. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
  - d. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
  - e. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Equipment Mounting: Install fire-alarm control unit on finished floor with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
  - a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
4. Install wall-mounted equipment, with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
  - a. Comply with requirements for seismic-restraint devices specified in Division 26 Section "Vibration And Seismic Controls For Electrical Systems".
5. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
  - a. Connect new equipment to existing control panel in existing part of the building.
  - b. Connect new equipment to existing monitoring equipment at the supervising station.



- c. Expand, modify, and supplement existing control **OR** monitoring, **as directed**, equipment as necessary to extend existing control **OR** monitoring, **as directed**, functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
  - 6. Smoke- or Heat-Detector Spacing:
    - a. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
    - b. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
    - c. Smooth ceiling spacing shall not exceed **30 feet (9 m)**
    - d. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B in NFPA 72.
    - e. HVAC: Locate detectors not closer than **3 feet (1 m) OR 5 feet (1.5 m)**, **as directed**, from air-supply diffuser or return-air opening.
    - f. Lighting Fixtures: Locate detectors not closer than **12 inches (300 mm)** from any part of a lighting fixture.
  - 7. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
  - 8. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
  - 9. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
  - 10. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
  - 11. Audible Alarm-Indicating Devices: Install not less than **6 inches (150 mm)** below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
  - 12. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least **6 inches (150 mm)** below the ceiling.
  - 13. Device Location-Indicating Lights: Locate in public space near the device they monitor.
  - 14. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
  - 15. Annunciator: Install with top of panel not more than **72 inches (1830 mm)** above the finished floor.
  - 16. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that will resist **100-mph (160-km/h)**, **as directed**, wind load with a gust factor of 1.3 without damage.
- B. Connections
- 1. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware". Connect hardware and devices to fire-alarm system.
    - a. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.
  - 2. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than **3 feet (1 m)** from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
    - a. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
    - b. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
    - c. Smoke dampers in air ducts of designated air-conditioning duct systems.
    - d. Alarm-initiating connection to elevator recall system and components.
    - e. Alarm-initiating connection to activate emergency lighting control.
    - f. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.



- g. Supervisory connections at valve supervisory switches.
  - h. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
  - i. Supervisory connections at elevator shunt trip breaker.
  - j. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
  - k. Supervisory connections at fire-pump engine control panel.
- C. Identification
- 1. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
  - 2. Install framed instructions in a location visible from fire-alarm control unit.
- D. Grounding
- 1. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- E. Field Quality Control
- 1. Field tests shall be witnessed by authorities having jurisdiction.
  - 2. Tests and Inspections:
    - a. Visual Inspection: Conduct visual inspection prior to testing.
      - 1) Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
      - 2) Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
    - b. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
    - c. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
    - d. Test audible appliances for the private operating mode according to manufacturer's written instructions.
    - e. Test visible appliances for the public operating mode according to manufacturer's written instructions.
    - f. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
  - 3. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
  - 4. Fire-alarm system will be considered defective if it does not pass tests and inspections.
  - 5. Prepare test and inspection reports.
  - 6. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
  - 7. Annual Test and Inspection: One year after date of Final Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

END OF SECTION 28 46 21 17

## SECTION 28 46 21 17a - ZONED (DC LOOP) FIRE-ALARM SYSTEM

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for zoned (DC loop) fire alarm system. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Fire-alarm control unit.
  - b. Manual fire-alarm boxes.
  - c. System smoke detectors.
  - d. Nonsystem smoke detectors.
  - e. Heat detectors.
  - f. Notification appliances.
  - g. Magnetic door holders.
  - h. Remote annunciator.
  - i. Digital alarm communicator transmitter.
  - j. Radio alarm transmitter.

#### C. Definitions

1. LED: Light-emitting diode.
2. NICET: National Institute for Certification in Engineering Technologies.

#### D. System Description

1. Noncoded system, dedicated to fire-alarm service only.

#### E. Submittals

1. General Submittal Requirements:
  - a. Submittals shall be approved by authorities having jurisdiction prior to submitting them to the Owner.
  - b. Shop Drawings shall be prepared by persons with the following qualifications:
    - 1) Trained and certified by manufacturer in fire-alarm system design.
    - 2) NICET-certified fire-alarm technician, Level III **OR** Level IV **OR** one who meets the requirements necessary for certification, **as directed**, minimum.
    - 3) Licensed or certified by authorities having jurisdiction.
2. Product Data: For each type of product indicated.
3. Shop Drawings: For fire-alarm system. Include plans, elevations, sections, details, and attachments to other work.
  - a. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
  - b. Include voltage drop calculations for notification appliance circuits.
  - c. Include battery size calculations.
  - d. Include performance parameters and installation details for each detector, verifying that each detector is listed for the complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
  - e. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators. Locate detectors according to manufacturer's written recommendations.





- f. Include floor plans to indicate final outlet locations showing zone designation of each device. Show size and route of cable and conduits.
    - 4. Delegated-Design Submittal: For smoke and heat detectors indicated to comply with performance requirements and design criteria, including analysis data, signed and sealed by the qualified professional engineer responsible for their preparation.
      - a. Drawings showing the location of each smoke and heat detector, the ratings of each, and installation details as needed to comply with the listing conditions of the detector.
      - b. Design Calculations: Calculate requirements for selecting the spacing and sensitivity of detection, complying with NFPA 72.
    - 5. Qualification Data: For qualified Installer.
    - 6. Field quality-control reports.
    - 7. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. Deliver copies to authorities having jurisdiction, **as directed**, and include the following:
      - a. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
      - b. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
      - c. Record copy of site-specific software.
      - d. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
        - 1) Frequency of testing of installed components.
        - 2) Frequency of inspection of installed components.
        - 3) Requirements and recommendations related to results of maintenance.
        - 4) Manufacturer's user training manuals.
      - e. Manufacturer's required maintenance related to system warranty requirements.
      - f. Abbreviated operating instructions for mounting at fire-alarm control unit.
      - g. Copy of NFPA 25.
- F. Quality Assurance
  - 1. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
  - 2. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level II **OR** Level III **OR** Level IV **OR** one who meets the requirements necessary for certification, **as directed**, technician.
  - 3. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer. Components shall be compatible with, and operate as, an extension of existing system.
  - 4. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- G. Project Conditions
  - 1. Interruption of Existing Fire-alarm Service: Do not interrupt fire-alarm service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary guard service according to requirements indicated:
    - a. Notify the Owner no fewer than two days in advance of proposed interruption of fire-alarm service.
    - b. Do not proceed with interruption of fire-alarm service without the Owner 's written permission.
- H. Sequencing And Scheduling
  - 1. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.

2. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

## 1.2 PRODUCTS

### A. Systems Operational Description

1. Fire-alarm signal initiation shall be by one or more of the following devices and systems, **as directed**:
  - a. Manual stations.
  - b. Heat detectors.
  - c. Smoke detectors.
  - d. Duct smoke detectors.
  - e. Automatic sprinkler system water flow.
  - f. Fire-extinguishing system operation.
  - g. Fire standpipe system.
2. Fire-alarm signal shall initiate the following actions:
  - a. Continuously operate alarm notification appliances.
  - b. Identify alarm zone at fire-alarm control unit and remote annunciators, **as directed**.
  - c. Transmit an alarm signal to the remote alarm receiving station.
3. Supervisory signal initiation shall be by one or more of the following devices and systems:
  - a. Valve supervisory switch.
4. System trouble signal initiation shall be by one or more of the following devices and actions:
  - a. Open circuits, shorts, and grounds in designated circuits.
  - b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
  - c. Loss of primary power at fire-alarm control unit.
  - d. Ground or a single break in fire-alarm control unit internal circuits.
  - e. Abnormal ac voltage at fire-alarm control unit.
  - f. Break in standby battery circuitry.
  - g. Failure of battery charging.
  - h. Abnormal position of any switch at fire-alarm control unit or annunciator, **as directed**.
5. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators, **as directed**.

### B. Fire-Alarm Control Unit

1. General Requirements for Fire-Alarm Control Unit:
  - a. Modular, power-limited design with electronic modules, UL 864 listed.
    - 1) Include a real-time clock for time annotation of events.
2. Alphanumeric Display and System Controls: Display alarm, supervisory, and component status messages and the programming and control menu.
  - a. Annunciator and Display: Liquid-crystal type, one line of 40 **OR** 80, **as directed**, characters, minimum.
3. Circuits:
  - a. No Fewer Than Five Initiating Device Circuits:
    - 1) Four circuits, NFPA 72, Class B.
    - 2) One circuit(s), NFPA 72, Class A, Style 6
  - b. No Fewer Than Two Notification Appliance Circuits: NFPA 72, Class B, Style Y.
4. Notification Appliance Circuit: Operation shall sound in a **<Insert pattern>**.
5. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be **OR** not be, **as directed**, connected to fire-alarm system.
6. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
7. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory signals **OR**



supervisory and digital alarm communicator transmitters **OR** digital alarm radio transmitters, **as directed**, shall be powered by the 24-V dc source.

- a. Alarm current draw of the entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
8. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
  - a. Batteries: Sealed lead calcium **OR** Sealed, valve-regulated, recombinant lead acid **OR** Vented, wet-cell pocket, plate nickel cadmium, **as directed**.
9. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

C. Manual Fire-Alarm Boxes

1. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
  - a. Single-action mechanism, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type.
  - b. Double-action mechanism requiring two actions to initiate an alarm, breaking-glass or plastic-rod **OR** pull-lever, **as directed**, type.
  - c. Station Reset: Key- or wrench-operated switch.
  - d. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
  - e. Weatherproof Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

D. System Smoke Detectors

1. General Requirements for System Smoke Detectors:
  - a. Operating at 24-V dc, nominal.
  - b. Detectors shall be four **OR** two, **as directed**, -wire type.
  - c. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
  - d. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
  - e. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.
  - f. Provide multiple levels of detection sensitivity for each sensor, with alarm-verification feature, **as directed**.
2. Photoelectric Smoke Detectors: Comply with UL 268.
3. Ionization Smoke Detector: Comply with UL 268.
4. Duct Smoke Detectors: Photoelectric type complying with UL 268A.
  - a. Remote indication and test, **as directed**, station. Operating key switch initiates an alarm test, **as directed**.
  - b. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
  - c. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
  - d. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

E. Nonsystem Smoke Detectors

1. Single-Station Smoke Detectors:

- a. Comply with UL 217; suitable for NFPA 101, residential occupancies; operating at 120-V ac with 9-V dc battery as the secondary power source. Provide with "low" or "missing" battery chirping-sound device, **as directed**.
- b. Auxiliary Relays: One Form C rated at 0.5 A **OR** Form A and one Form C, both rated at 0.5 A, **as directed**.
- c. Audible Notification Appliance: Piezoelectric sounder rated at 90 dBA at 10 feet (3 m) according to UL 464.
- d. Visible Notification Appliance: 177-cd strobe.
- e. Heat sensor, 135 deg F (57 deg C) combination rate-of-rise and fixed temperature, **as directed**.
- f. Test Switch: Push-to-test; simulates smoke at rated obscuration.
- g. Tandem Connection: Allow tandem connection of number of indicated detectors; alarm on one detector shall actuate notification on all connected detectors.
- h. Plug-in Arrangement: Detector and associated electronic components shall be mounted in a plug-in module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
- i. Self-Restoring: Detectors shall not require resetting or readjustment after actuation to restore them to normal operation.
- j. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status, **as directed**.
- 2. Single-Station Duct Smoke Detectors:
  - a. Comply with UL 268A; operating at 120-V ac.
  - b. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. The fixed base shall be designed for mounting directly to air duct. Provide terminals in the fixed base for connection to building wiring.
    - 1) Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
  - c. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
  - d. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.
- F. Heat Detectors
  - 1. General Requirements for Heat Detectors: Comply with UL 521.
  - 2. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135 deg F (57 deg C) or a rate of rise that exceeds 15 deg F (8 deg C) per minute unless otherwise indicated.
    - a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
  - 3. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of 190 deg F (88 deg C).
    - a. Mounting: Adapter plate for outlet box mounting **OR** Twist-lock base interchangeable with smoke-detector bases, **as directed**.
- G. Notification Appliances
  - 1. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
    - a. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
  - 2. Chimes, High-Level Output: Vibrating type, 81-dBA minimum rated output.
  - 3. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet (3 m) from the horn, using the coded signal prescribed in UL 464 test protocol.



4. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum **1-inch- (25-mm-)** high letters on the lens.
  - a. Rated Light Output:
    - 1) Indicated on Drawings.
    - 2) **15 OR 30 OR 75 OR 110 OR 177, as directed, cd.**  
**OR**  
15/30/75/110 cd, selectable in the field.
  - b. Mounting: Indicated on Drawings **OR** Wall mounted, **as directed**.
  - c. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
  - d. Flashing shall be in a temporal pattern, synchronized with other units.
  - e. Strobe Leads: Factory connected to screw terminals.
  - f. Mounting Faceplate: Factory finished, red **OR** white, **as directed**.
- H. Magnetic Door Holders
  1. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
    - a. Electromagnet: Requires no more than 3 W to develop **25-lbf (111-N)** holding force.
    - b. Wall-Mounted Units: Flush mounted unless otherwise indicated.
    - c. Rating: 24-V ac or dc.
    - d. Rating: 120-V ac.
  2. Material and Finish: Match door hardware.
- I. Remote Annunciator
  1. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
    - a. Mounting: Flush **OR** Surface, **as directed**, cabinet, NEMA 250, Type 1.
  2. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.
- J. Digital Alarm Communicator Transmitter
  1. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.
  2. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture one **OR** two, **as directed**, telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either, **as directed**, line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
  3. Local functions and display at the digital alarm communicator transmitter shall include the following:
    - a. Verification that both telephone lines are available.
    - b. Programming device.
    - c. LED display.
    - d. Manual test report function and manual transmission clear indication.
    - e. Communications failure with the central station or fire-alarm control unit.
  4. Digital data transmission shall include the following:
    - a. Zone of the alarm initiating device.
    - b. Zone of the supervisory signal.
    - c. Zone of the trouble initiating device.

- d. Loss of ac supply or loss of power.
  - e. Low battery.
  - f. Abnormal test signal.
  - g. Communication bus failure.
  5. Secondary Power: Integral rechargeable battery and automatic charger.
  6. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.
- K. Radio Alarm Transmitter
1. Transmitter shall comply with NFPA 1221 and shall be listed and labeled by an NRTL.
  2. Comply with 47 CFR 90.
  3. Description: Manufacturer's standard commercial product; factory assembled, wired, tested, and ready for installation and operation.
    - a. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
    - b. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by the Owner.
    - c. Normal Power Input: 120-V ac.
    - d. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
    - e. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance. Wind-load strength of antenna and mounting hardware and supports shall withstand 100 mph (160 km/h) with a gust factor of 1.3 without failure.
    - f. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
    - g. Antenna-Cable Connectors: Weatherproof.
    - h. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire-alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.
  4. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit or from its own internal sensors or controls and shall automatically transmit signal along with a unique code that identifies the transmitting station to the remote alarm receiving station. Transmitted messages shall correspond to standard designations for fire-reporting system to which the signal is being transmitted and shall include separately designated messages in response to the following events or conditions:
    - a. Transmitter Low-Battery Condition: Sent when battery voltage is below 85 percent of rated value.
    - b. System Test Message: Initiated manually by a test switch within the transmitter cabinet, or automatically at an optionally preselected time, once every 24 hours, with transmission time controlled by a programmed timing device integral to transmitter controls.
    - c. Transmitter Trouble Message: Actuated by failure, in excess of one-minute duration, of the transmitter normal power source, derangement of the wiring of the transmitter, or any alarm input interface circuit or device connected to it.
    - d. Local Fire-Alarm-System Trouble Message: Initiated by events or conditions that cause a trouble signal to be indicated on the building system.
    - e. Local Fire-Alarm-System Alarm Message: Actuated when the building system goes into an alarm state. Identifies device that initiated the alarm.
    - f. Local Fire-Alarm-System Supervisory-Alarm Message: Actuated when the building alarm system indicates a supervisory alarm, **as directed**.
- L. Device Guards
1. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
    - a. Factory fabricated and furnished by manufacturer of the device.
    - b. Finish: Paint of color to match the protected device.



### 1.3 EXECUTION

#### A. Equipment Installation

1. Comply with NFPA 72 for installation of fire-alarm equipment.
2. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
  - a. Connect new equipment to the existing control panel in the existing part of the building.
  - b. Connect new equipment to the existing monitoring equipment at the supervising station.
  - c. Expand, modify, and supplement the existing control **OR** monitoring, **as directed**, equipment as necessary to extend the existing control **OR** monitoring, **as directed**, functions to the new points. New components shall be capable of merging with the existing configuration without degrading the performance of either system.
3. Smoke- or Heat-Detector Spacing:
  - a. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.
  - b. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
  - c. Smooth ceiling spacing shall not exceed **30 feet (9 m)**, **as directed**.
  - d. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A or Appendix B, **as directed**, in NFPA 72.
  - e. HVAC: Locate detectors not closer than **3 feet (1 m) OR 5 feet (1.5 m)**, **as directed**, from air-supply diffuser or return-air opening.
  - f. Lighting Fixtures: Locate detectors not closer than **12 inches (300 mm)** from any part of a lighting fixture.
4. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
5. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
6. Single-Station Smoke Detectors: Where more than one smoke alarm is installed within a dwelling or suite, they shall be connected so that the operation of any smoke alarm causes the alarm in all smoke alarms to sound.
7. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
8. Audible Alarm-Indicating Devices: Install not less than **6 inches (150 mm)** below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
9. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least **6 inches (150 mm)** below the ceiling.
10. Device Location-Indicating Lights: Locate in public space near the device they monitor.
11. Fire-Alarm Control Unit: Surface mounting, with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
12. Annunciator: Install with top of panel not more than **72 inches (1830 mm)** above the finished floor.
13. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that will resist **100-mph (160-km/h)**, **as directed**, wind load with a gust factor of 1.3 without damage.

#### B. Connections

1. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware". Connect hardware and devices to fire-alarm system.
  - a. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.



2. Connect supervised interface devices to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled.
  - a. Smoke dampers in air ducts of designated air-conditioning duct systems.
  - b. Supervisory connections at valve supervisory switches.
  - c. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
  - d. Supervisory connections at fire-pump engine control panel.
- C. Identification
  1. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification For Electrical Systems".
  2. Install framed instructions in a location visible from fire-alarm control unit.
- D. Grounding
  1. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.
- E. Field Quality Control
  1. Field tests shall be witnessed by authorities having jurisdiction.
  2. Tests and Inspections:
    - a. Visual Inspection: Conduct the visual inspection prior to testing.
      - 1) Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
      - 2) Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
    - b. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing, and Maintenance" Chapter in NFPA 72.
    - c. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
    - d. Test visible appliances for the public operating mode according to manufacturer's written instructions.
    - e. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
  3. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
  4. Fire-alarm system will be considered defective if it does not pass tests and inspections.
  5. Prepare test and inspection reports.
  6. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.
  7. Annual Test and Inspection: One year after date of Final Completion, test fire-alarm system complying with the visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

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Task	Specification	Specification Description
28 49 11 00	28 16 11 00	Perimeter Security
28 49 11 00	28 16 11 00a	Intrusion Detection
28 49 11 00	28 16 11 00b	Security Access

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## SECTION 31 01 20 00 - EARTHWORK

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for earthwork. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
  - b. Excavating and backfilling for buildings and structures.
  - c. Drainage course for concrete slabs-on-grade.
  - d. Subbase course for concrete walks and pavements.
  - e. Subbase course and base course for asphalt paving.
  - f. Subsurface drainage backfill for walls and trenches.
  - g. Excavating and backfilling trenches for utilities and pits for buried utility structures.
  - h. Excavating well hole to accommodate elevator-cylinder assembly.

#### C. Definitions

1. Backfill: Soil material or controlled low-strength material used to fill an excavation.
  - a. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
  - b. Final Backfill: Backfill placed over initial backfill to fill a trench.
2. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.
3. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.
4. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.
5. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.
6. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
  - a. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by the Owner. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
  - b. Bulk Excavation: Excavation more than 10 feet (3 m) in width and more than 30 feet (9 m) in length.
  - c. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by the Owner. Unauthorized excavation, as well as remedial work directed by the Owner, shall be without additional compensation.
7. Fill: Soil materials used to raise existing grades.
8. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that exceed 1 cu. yd. (0.76 cu. m) for bulk excavation or 3/4 cu. yd. (0.57 cu. m) for footing, trench, and pit excavation that cannot be removed by rock excavating equipment equivalent to the following in size and performance ratings, without systematic drilling, ram hammering, ripping, or blasting, when permitted:
  - a. Excavation of Footings, Trenches, and Pits: Late-model, track-mounted hydraulic excavator; equipped with a 42-inch- (1065-mm-) wide, maximum, short-tip-radius rock bucket; rated at not less than 138-hp (103-kW) flywheel power with bucket-curling force of not less than 28,700 lbf (128 kN) and stick-crowd force of not less than 18,400 lbf (82 kN) with extra-long reach boom; measured according to SAE J-1179.

- b. Bulk Excavation: Late-model, track-mounted loader; rated at not less than **230-hp (172-kW)** flywheel power and developing a minimum of **47,992-lbf (213.3-kN)** breakout force with a general-purpose bare bucket; measured according to SAE J-732.
- 9. If Standard Penetration Values are used to Define Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material **3/4 cu. yd. (0.57 cu. m)** or more in volume that exceed a standard penetration resistance of **100 blows/2 inches (97 blows/50 mm)** when tested by a geotechnical testing agency, according to ASTM D 1586.
- 10. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.
- 11. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.
- 12. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.
- 13. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

D. Submittals

- 1. Product Data: For each type of the following manufactured products required:
  - a. Geotextiles.
  - b. Controlled low-strength material, including design mixture.
  - c. Geofoam.
  - d. Warning tapes.
- 2. Samples: For the following products, in sizes indicated below:
  - a. Geotextile: **12 by 12 inches (300 by 300 mm)**.
  - b. Warning Tape: **12 inches (300 mm)** long; of each color.
- 3. Qualification Data: For qualified testing agency.
- 4. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
  - a. Classification according to ASTM D 2487.
  - b. Laboratory compaction curve according to ASTM D 698 **OR** ASTM D 1557, **as directed**.
- 5. Blasting plan approved by authorities having jurisdiction.
- 6. Seismic survey report from seismic survey agency.
- 7. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

E. Quality Assurance

- 1. Blasting:
  - a. Blasting will not be allowed.
  - OR**
  - Comply with applicable requirements in NFPA 495, "Explosive Materials Code," and prepare a blasting plan reporting the following:
    - 1) Types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.
    - 2) Seismographic monitoring during blasting operations.
- 2. Seismic Survey Agency: An independent testing agency, acceptable to authorities having jurisdiction, experienced in seismic surveys and blasting procedures to perform the following services:
  - a. Report types of explosive and sizes of charge to be used in each area of rock removal, types of blasting mats, sequence of blasting operations, and procedures that will prevent damage to site improvements and structures on Project site and adjacent properties.

- b. Seismographic monitoring during blasting operations.
3. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.
4. Pre-excavation Conference: Conduct conference at Project site.

F. Project Conditions

1. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.
  - a. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction.
  - b. Provide alternate routes around closed or obstructed traffic ways if required by the Owner or authorities having jurisdiction.
2. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining the Owner's property will be obtained by the Owner before award of Contract.
3. Do not proceed with work on adjoining property until directed by the Owner.
4. Utility Locator Service: Notify utility locator service **OR** "Miss Utility" **OR** "Call Before You Dig" **OR** "Dig Safe System" **OR** "One Call", **as directed**, for area where Project is located before beginning earth moving operations.
5. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Division 01 Section(s) "Temporary Facilities And Controls" **OR** Division 31 Section(s) "Site Clearing", **as directed**, are in place.
6. Do not commence earth moving operations until plant-protection measures specified in Division 01 Section "Temporary Tree And Plant Protection" are in place.
7. The following practices are prohibited within protection zones:
  - a. Storage of construction materials, debris, or excavated material.
  - b. Parking vehicles or equipment.
  - c. Foot traffic.
  - d. Erection of sheds or structures.
  - e. Impoundment of water.
  - f. Excavation or other digging unless otherwise indicated.
  - g. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
8. Do not direct vehicle or equipment exhaust towards protection zones.
9. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

1.2 PRODUCTS

A. Soil Materials

1. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
2. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487 **OR** Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, **as directed**, or a combination of these groups; free of rock or gravel larger than **3 inches (75 mm)** in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
3. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487 **OR** Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, **as directed**, or a combination of these groups.
  - a. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.
4. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a **1-1/2-inch (37.5-mm)** sieve and not more than 12 percent passing a **No. 200 (0.075-mm)** sieve.
5. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 95 percent passing a **1-1/2-inch (37.5-mm)** sieve and not more than 8 percent passing a **No. 200 (0.075-mm)** sieve.

6. Engineered Fill: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; with at least 90 percent passing a **1-1/2-inch (37.5-mm)** sieve and not more than 12 percent passing a **No. 200 (0.075-mm)** sieve.
7. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a **1-inch (25-mm)** sieve and not more than 8 percent passing a **No. 200 (0.075-mm)** sieve.
8. Drainage Course: Narrowly graded mixture of washed, **as directed**, crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a **1-1/2-inch (37.5-mm)** sieve and 0 to 5 percent passing a **No. 8 (2.36-mm)** sieve.
9. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a **1-inch (25-mm)** sieve and 0 to 5 percent passing a **No. 4 (4.75-mm)** sieve.
10. Sand: ASTM C 33; fine aggregate.
11. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

B. Geotextiles

1. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
  - a. Survivability: Class 2; AASHTO M 288.
  - b. Apparent Opening Size: **No. 40 (0.425-mm) OR No. 60 (0.250-mm) OR No. 70 (0.212-mm)**, **as directed**, sieve, maximum; ASTM D 4751.
  - c. Permittivity: 0.5 **OR** 0.2 **OR** 0.1, **as directed**, per second, minimum; ASTM D 4491.
  - d. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.
2. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
  - a. Survivability: Class 2; AASHTO M 288.
  - b. Apparent Opening Size: **No. 60 (0.250-mm)** sieve, maximum; ASTM D 4751.
  - c. Permittivity: 0.02 per second, minimum; ASTM D 4491.
  - d. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

C. Controlled Low-Strength Material

1. Controlled Low-Strength Material: Self-compacting, low-density, **as directed**, flowable concrete material produced from the following:
  - a. Portland Cement: ASTM C 150, Type I **OR** Type II **OR** Type III, **as directed**.
  - b. Fly Ash: ASTM C 618, Class C or F.
  - c. Normal-Weight Aggregate: ASTM C 33, **3/4-inch (19-mm) OR 3/8-inch (10-mm)**, **as directed**, nominal maximum aggregate size.
  - d. Foaming Agent (if low-density, controlled low-strength material is required): ASTM C 869.
  - e. Water: ASTM C 94/C 94M.
  - f. Air-Entraining Admixture (not required for low-density, controlled low-strength material using foaming agent): ASTM C 260.
2. Produce low-density, controlled low-strength material with the following physical properties:
  - a. As-Cast Unit Weight: **30 to 36 lb/cu. ft. (480 to 576 kg/cu. m) OR 36 to 42 lb/cu. ft. (576 to 675 kg/cu. m)**, **as directed**, at point of placement, when tested according to ASTM C 138/C 138M.
  - b. Compressive Strength: **80 psi (550 kPa) OR 140 psi (965 kPa)**, **as directed**, when tested according to ASTM C 495.

**OR**

Produce conventional-weight, controlled low-strength material with **80-psi (550-kPa) OR 140-psi (965-kPa)**, **as directed**, compressive strength when tested according to ASTM C 495.

D. Geofoam

1. Extruded-Polystyrene Board Insulation: ASTM C 578, Type IV, 1.55-lb/cu. ft. (25-kg/cu. m) density, 25-psi (173-kPa) compressive strength OR Type X, 1.30-lb/cu. ft. (21-kg/cu. m) density, 15-psi (104-kPa) compressive strength OR Type VI, 1.80-lb/cu. ft. (29-kg/cu. m) density, 40-psi (276-kPa) compressive strength OR Type VII, 2.20-lb/cu. ft. (35-kg/cu. m) density, 60-psi (414-kPa) compressive strength OR Type V, 3.00-lb/cu. ft. (48-kg/cu. m) density, 100-psi (690-kPa) compressive strength, **as directed**.
2. Molded-Polystyrene Board Insulation: ASTM C 578, Type I, 0.90-lb/cu. ft. (15-kg/cu. m) density, 10-psi (69-kPa) compressive strength OR Type VIII, 1.15-lb/cu. ft. (18-kg/cu. m) density, 13-psi (90-kPa) compressive strength OR Type II, 1.35-lb/cu. ft. (22-kg/cu. m) density, 15-psi (104-kPa) compressive strength, **as directed**.
  - a. Manufacture molded polystyrene with an inorganic mineral registered with the EPA and suitable for application as a termite deterrent.
3. Rigid Cellular Polystyrene Geofoam: ASTM D 6817, Type EPS 19, 1.15-lb/cu. ft. (18.4-kg/cu. m) density, 5.8-psi (40-kPa) compressive strength at 1 percent deformation; 16-psi (110-kPa) compressive strength at 10 percent deformation OR Type EPS 39, 2.40-lb/cu. ft. (38.4-kg/cu. m) density, 15-psi (103-kPa) compressive strength at 1 percent deformation; 40-psi (276-kPa) compressive strength at 10 percent deformation, **as directed**.
4. Connectors: Geofoam manufacturer's multibarbed, galvanized-steel sheet connectors OR Deformed steel reinforcing bars, 3/4 inch (19 mm) in diameter, **as directed**.

E. Accessories

1. Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility; colored as follows:
  - a. Red: Electric.
  - b. Yellow: Gas, oil, steam, and dangerous materials.
  - c. Orange: Telephone and other communications.
  - d. Blue: Water systems.
  - e. Green: Sewer systems.

**OR**

Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored as follows:

  - f. Red: Electric.
  - g. Yellow: Gas, oil, steam, and dangerous materials.
  - h. Orange: Telephone and other communications.
  - i. Blue: Water systems.
  - j. Green: Sewer systems.

1.3 EXECUTION

A. Preparation

1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.
2. Protect and maintain erosion and sedimentation controls during earth moving operations.
3. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

B. Dewatering

1. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.



2. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.
  - a. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

C. Explosives

1. Explosives: Do not use explosives.

**OR**

Explosives: Obtain written permission from authorities having jurisdiction before bringing explosives to Project site or using explosives on Project site.

- a. Perform blasting without damaging adjacent structures, property, or site improvements.
- b. Perform blasting without weakening the bearing capacity of rock subgrade and with the least-practicable disturbance to rock to remain.

D. Excavation, General

1. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
  - a. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
  - b. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:
    - 1) 24 inches (600 mm) outside of concrete forms other than at footings.
    - 2) 12 inches (300 mm) outside of concrete forms at footings.
    - 3) 6 inches (150 mm) outside of minimum required dimensions of concrete cast against grade.
    - 4) Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
    - 5) 6 inches (150 mm) beneath bottom of concrete slabs-on-grade.
    - 6) 6 inches (150 mm) beneath pipe in trenches, and the greater of 24 inches (600 mm) wider than pipe or 42 inches (1065 mm) wide.
2. Classified Excavation: Excavate to subgrade elevations. Material to be excavated will be classified as earth and rock. Do not excavate rock until it has been classified and cross sectioned by the Owner. The Contract Sum will be adjusted for rock excavation according to unit prices included in the Contract Documents. Changes in the Contract Time may be authorized for rock excavation.
  - a. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.
    - 1) Intermittent drilling; blasting, if permitted; ram hammering; or ripping of material not classified as rock excavation is earth excavation.
  - b. Rock excavation includes removal and disposal of rock. Remove rock to lines and subgrade elevations indicated to permit installation of permanent construction without exceeding the following dimensions:
    - 1) 24 inches (600 mm) outside of concrete forms other than at footings.
    - 2) 12 inches (300 mm) outside of concrete forms at footings.
    - 3) 6 inches (150 mm) outside of minimum required dimensions of concrete cast against grade.
    - 4) Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
    - 5) 6 inches (150 mm) beneath bottom of concrete slabs-on-grade.
    - 6) 6 inches (150 mm) beneath pipe in trenches, and the greater of 24 inches (600 mm) wider than pipe or 42 inches (1065 mm) wide.

E. Excavation For Structures

1. Excavate to indicated elevations and dimensions within a tolerance of plus or minus **1 inch (25 mm)**. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
  - a. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
  - b. Pile Foundations: Stop excavations **6 to 12 inches (150 to 300 mm)** above bottom of pile cap before piles are placed. After piles have been driven, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete pile caps.
  - c. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus **1 inch (25 mm)**. Do not disturb bottom of excavations intended as bearing surfaces.
2. Excavations at Edges of Tree- and Plant-Protection Zones:
  - a. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
  - b. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree And Plant Protection".

F. Excavation For Walks And Pavements

1. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

G. Excavation For Utility Trenches

1. Excavate trenches to indicated gradients, lines, depths, and elevations.
  - a. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.
2. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to **12 inches (300 mm)** higher than top of pipe or conduit unless otherwise indicated.
  - a. Clearance: **12 inches (300 mm)** each side of pipe or conduit **OR** As indicated, **as directed**.
3. Trench Bottoms (if a bedding course is not required under pipe and conduit): Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.
  - a. For pipes and conduit less than **6 inches (150 mm)** in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
  - b. For pipes and conduit **6 inches (150 mm)** or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.
  - c. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
  - d. Excavate trenches **6 inches (150 mm)** deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
4. Trench Bottoms (if a bedding course is required under pipe and conduit): Excavate trenches **4 inches (100 mm)** deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.
  - a. Excavate trenches **6 inches (150 mm)** deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.
5. Trenches in Tree- and Plant-Protection Zones:
  - a. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.



- b. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
  - c. Cut and protect roots according to requirements in Division 01 Section "Temporary Tree And Plant Protection".
- H. Excavation For Elevator Cylinder
  - 1. Drill well hole plumb in elevator pit to accommodate installation of elevator-cylinder assembly. Coordinate with applicable requirements for diameter and tolerances in Division 14 Section(s) "Hydraulic Elevators" OR "Hydraulic Freight Elevators", **as directed**.
  - 2. Provide well casing as necessary to retain walls of well hole.
- I. Subgrade Inspection
  - 1. Notify the Owner when excavations have reached required subgrade.
  - 2. If the Owner determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
  - 3. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than **15 tons (13.6 tonnes)** to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
    - a. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to **3 mph (5 km/h)**.
    - b. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the Owner, and replace with compacted backfill or fill as directed.
  - 4. Authorized additional excavation and replacement material will be paid for according to Contract provisions for changes in the Work.
  - 5. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Owner, without additional compensation.
- J. Unauthorized Excavation
  - 1. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of **2500 psi (17.2 MPa)**, may be used when approved by the Owner.
    - a. Fill unauthorized excavations under other construction, pipe, or conduit as directed by the Owner.
- K. Storage Of Soil Materials
  - 1. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
    - a. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
- L. Backfill
  - 1. Place and compact backfill in excavations promptly, but not before completing the following:
    - a. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
    - b. Surveying locations of underground utilities for Record Documents.
    - c. Testing and inspecting underground utilities.
    - d. Removing concrete formwork.
    - e. Removing trash and debris.
    - f. Removing temporary shoring and bracing, and sheeting.
    - g. Installing permanent or temporary horizontal bracing on horizontally supported walls.
  - 2. Place backfill on subgrades free of mud, frost, snow, or ice.
- M. Utility Trench Backfill
  - 1. Place backfill on subgrades free of mud, frost, snow, or ice.

2. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
3. Trenches under Footings: Backfill trenches excavated under footings and within **18 inches (450 mm)** of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
4. Trenches under Roadways: Provide **4-inch- (100-mm-)** thick, concrete-base slab support for piping or conduit less than **30 inches (750 mm)** below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of **4 inches (100 mm)** of concrete before backfilling or placing roadway subbase course. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
5. Backfill voids with satisfactory soil while removing shoring and bracing.
6. If soil material is required as initial backfill, place and compact initial backfill of subbase material **OR** satisfactory soil, **as directed**, free of particles larger than **1 inch (25 mm)** in any dimension, to a height of **12 inches (300 mm)** over the pipe or conduit.
  - a. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.
7. Controlled Low-Strength Material: If controlled low-strength material is permitted or required as initial backfill, place initial backfill of controlled low-strength material to a height of **12 inches (300 mm)** over the pipe or conduit. Coordinate backfilling with utilities testing.
8. If satisfactory soil material is required as final backfill, place and compact final backfill of satisfactory soil to final subgrade elevation.
9. Controlled Low-Strength Material: If controlled low-strength material is permitted or required as final backfill, place final backfill of controlled low-strength material to final subgrade elevation.
10. Install warning tape directly above utilities, **12 inches (300 mm)** below finished grade, except **6 inches (150 mm)** below subgrade under pavements and slabs.

N. Soil Fill

1. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.
2. Place and compact fill material in layers to required elevations as follows:
  - a. Under grass and planted areas, use satisfactory soil material.
  - b. Under walks and pavements, use satisfactory soil material.
  - c. Under steps and ramps, use engineered fill.
  - d. Under building slabs, use engineered fill.
  - e. Under footings and foundations, use engineered fill.
3. Place soil fill on subgrades free of mud, frost, snow, or ice.

O. Geofoam Fill

1. Place a leveling course of sand, **2 inches (50 mm)** thick, over subgrade. Finish leveling course to a tolerance of **1/2 inch (13 mm)** when tested with a **10-foot (3-m)** straightedge.
  - a. Place leveling course on subgrades free of mud, frost, snow, or ice.
  - b. Install geofoam blocks in layers with abutting edges and ends and with the long dimension of each block at right angles to blocks in each subsequent layer. Offset joints of blocks in successive layers.
  - c. Install geofoam connectors at each layer of geofoam to resist horizontal displacement according to geofoam manufacturer's written instructions.
2. Cover geofoam with subdrainage **OR** separation, **as directed**, geotextile before placing overlying soil materials.

P. Soil Moisture Control

1. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.
  - a. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.

- b. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

Q. Compaction Of Soil Backfills And Fills

1. Place backfill and fill soil materials in layers not more than **8 inches (200 mm)** in loose depth for material compacted by heavy compaction equipment, and not more than **4 inches (100 mm)** in loose depth for material compacted by hand-operated tampers.
2. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
3. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 698 **OR** ASTM D 1557, **as directed**:
  - a. Under structures, building slabs, steps, and pavements, scarify and recompact top **12 inches (300 mm)** of existing subgrade and each layer of backfill or fill soil material at 95 percent.
  - b. Under walkways, scarify and recompact top **6 inches (150 mm)** below subgrade and compact each layer of backfill or fill soil material at 92 percent.
  - c. Under turf or unpaved areas, scarify and recompact top **6 inches (150 mm)** below subgrade and compact each layer of backfill or fill soil material at 85 percent.
  - d. For utility trenches, compact each layer of initial and final backfill soil material at 85 percent.

R. Grading

1. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.
  - a. Provide a smooth transition between adjacent existing grades and new grades.
  - b. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
2. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:
  - a. Turf or Unpaved Areas: Plus or minus **1 inch (25 mm)**.
  - b. Walks: Plus or minus **1 inch (25 mm)**.
  - c. Pavements: Plus or minus **1/2 inch (13 mm)**.
3. Grading inside Building Lines: Finish subgrade to a tolerance of **1/2 inch (13 mm)** when tested with a **10-foot (3-m)** straightedge.

S. Subsurface Drainage

1. Subdrainage Pipe: Specified in Division 33 Section "Storm Utility Drainage Piping".
2. Subsurface Drain: If nonwoven geotextile is used in subsurface drainage applications, place subsurface drainage geotextile around perimeter of subdrainage trench. Place a **6-inch (150-mm)** course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of **12 inches (300 mm)** of filter material, placed in compacted layers **6 inches (150 mm)** thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least **6 inches (150 mm)**.
  - a. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698 **OR** with a minimum of two passes of a plate-type vibratory compactor, **as directed**.
3. Drainage Backfill: If using free-draining granular backfill against walls, place and compact filter material over subsurface drain, in width indicated, to within **12 inches (300 mm)** of final subgrade, in compacted layers **6 inches (150 mm)** thick. Overlay drainage backfill with one layer of subsurface drainage geotextile, overlapping sides and ends at least **6 inches (150 mm)**.
  - a. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 698 **OR** with a minimum of two passes of a plate-type vibratory compactor, **as directed**.



- b. Place and compact impervious fill over drainage backfill in **6-inch- (150-mm-)** thick compacted layers to final subgrade.
- T. Subbase And Base Courses Under Pavements And Walks
  1. Place subbase course and base course, **as directed**, on subgrades free of mud, frost, snow, or ice.
  2. On prepared subgrade, place subbase course and base course, **as directed**, under pavements and walks as follows:
    - a. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
    - b. Place base course material over subbase course under hot-mix asphalt pavement.
    - c. Shape subbase course and base course, **as directed**, to required crown elevations and cross-slope grades.
    - d. Place subbase course and base course, **as directed**, **6 inches (150 mm)** or less in compacted thickness in a single layer.
    - e. Place subbase course and base course, **as directed**, that exceeds **6 inches (150 mm)** in compacted thickness in layers of equal thickness, with no compacted layer more than **6 inches (150 mm)** thick or less than **3 inches (75 mm)** thick.
    - f. Compact subbase course and base course, **as directed**, at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 698 **OR** ASTM D 1557, **as directed**.
  3. Pavement Shoulders: Place shoulders along edges of subbase course and base course, **as directed**, to prevent lateral movement. Construct shoulders, at least **12 inches (300 mm)** wide, of satisfactory soil materials and compact simultaneously with each subbase and base, **as directed**, layer to not less than 95 percent of maximum dry unit weight according to ASTM D 698 **OR** ASTM D 1557, **as directed**.
- U. Drainage Course Under Concrete Slabs-On-Grade
  1. Place drainage course on subgrades free of mud, frost, snow, or ice.
  2. On prepared subgrade, place and compact drainage course under cast-in-place concrete slabs-on-grade as follows:
    - a. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
    - b. Place drainage course **6 inches (150 mm)** or less in compacted thickness in a single layer.
    - c. Place drainage course that exceeds **6 inches (150 mm)** in compacted thickness in layers of equal thickness, with no compacted layer more than **6 inches (150 mm)** thick or less than **3 inches (75 mm)** thick.
    - d. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 698.
- V. Field Quality Control
  1. Special Inspections: If special inspections are required by code, engage a qualified special inspector to perform the following special inspections:
    - a. Determine prior to placement of fill that site has been prepared in compliance with requirements.
    - b. Determine that fill material and maximum lift thickness comply with requirements.
    - c. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.
  2. Testing Agency: Engage a qualified geotechnical engineering testing agency to perform tests and inspections.
  3. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
  4. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing

subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by the Owner.

5. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
  - a. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every **2000 sq. ft. (186 sq. m)** or less of paved area or building slab, but in no case fewer than three tests.
  - b. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every **100 feet (30 m)** or less of wall length, but no fewer than two tests.
  - c. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every **150 feet (46 m)** or less of trench length, but no fewer than two tests.
6. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

W. Protection

1. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
2. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
  - a. Scarify or remove and replace soil material to depth as directed by the Owner; reshape and recompact.
3. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
  - a. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

X. Disposal Of Surplus And Waste Materials

1. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off the Owner's property.

**OR**

Transport surplus satisfactory soil to designated storage areas on the Owner's property. Stockpile or spread soil as directed by the Owner.

  - a. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off the Owner's property.

END OF SECTION 31 01 20 00

## SECTION 31 05 13 00 - SUBDRAINAGE

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for subdrainage. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Perforated-wall pipe and fittings.
  - b. Drainage conduits.
  - c. Drainage panels.
  - d. Geotextile filter fabrics.

#### C. Submittals

1. Drainage conduits, including rated capacities.
2. Drainage panels, including rated capacities.
3. Geotextile filter fabrics.

### 1.2 PRODUCTS

#### A. Perforated-Wall Pipes And Fittings

1. Perforated PE Pipe and Fittings:
  - a. **NPS 6 (DN 150)** and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
  - b. **NPS 8 (DN 200)** and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
  - c. Couplings: Manufacturer's standard, band type.
2. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.
3. Perforated Clay Pipe and Fittings: ASTM C 700, Standard- and Extra-Strength classes, unglazed, socket-and-spigot ends, for gasketed joints.
  - a. Gaskets: ASTM C 425, rubber.
4. Perforated Concrete Pipe and Fittings: **ASTM C 444 (ASTM C 444M)**, Type 1, and applicable requirements in **ASTM C 14 (ASTM C 14M)**, Class 2, socket-and-spigot ends for gasketed joints.
  - a. Gaskets: **ASTM C 443 (ASTM C 443M)**, rubber.

#### B. Drainage Conduits

1. Molded-Sheet Drainage Conduits: Prefabricated geocomposite with cusped, molded-plastic drainage core wrapped in geotextile filter fabric.
  - a. Nominal Size: **12 inches (305 mm)** high by approximately **1 inch (25 mm)** thick.
    - 1) Minimum In-Plane Flow: **30 gpm (114 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - b. Nominal Size: **18 inches (457 mm)** high by approximately **1 inch (25 mm)** thick.
    - 1) Minimum In-Plane Flow: **45 gpm (170 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - c. Filter Fabric: PP geotextile.
  - d. Fittings: HDPE with combination **NPS 4 and NPS 6 (DN 100 and DN 150)** outlet connection.



2. **Multipipe Drainage Conduits:** Prefabricated geocomposite with interconnected, corrugated, perforated-pipe core molded from HDPE complying with ASTM D 1248 and wrapped in geotextile filter fabric.
  - a. Nominal Size: **6 inches (152 mm)** high by approximately **1-1/4 inches (31 mm)** thick.
    - 1) Minimum In-Plane Flow: **15 gpm (57 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - b. Nominal Size: **12 inches (305 mm)** high by approximately **1-1/4 inches (31 mm)** thick.
    - 1) Minimum In-Plane Flow: **30 gpm (114 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - c. Nominal Size: **18 inches (457 mm)** high by approximately **1-1/4 inches (31 mm)** thick.
    - 1) Minimum In-Plane Flow: **45 gpm (170 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - d. Filter Fabric: Nonwoven, needle-punched geotextile.
  - e. Fittings: HDPE with combination **NPS 4 and NPS 6 (DN 100 and DN 150)** outlet connection.
  - f. Couplings: HDPE.
3. **Single-Pipe Drainage Conduits:** Prefabricated geocomposite with perforated corrugated core molded from HDPE complying with ASTM D 3350 and wrapped in geotextile filter fabric.
  - a. Nominal Size: **12 inches (305 mm)** high by approximately **1 inch (25 mm)** thick.
    - 1) Minimum In-Plane Flow: **30 gpm (114 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - b. Nominal Size: **18 inches (457 mm)** high by approximately **1 inch (25 mm)** thick.
    - 1) Minimum In-Plane Flow: **45 gpm (170 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - c. Filter Fabric: Nonwoven, PP geotextile.
  - d. Fittings: HDPE with combination **NPS 4 and NPS 6 (DN 100 and DN 150)** outlet connection.
  - e. Couplings: Corrugated HDPE band.
4. **Mesh Fabric Drainage Conduits:** Prefabricated geocomposite with plastic-filament drainage core wrapped in geotextile filter fabric. Include fittings for bends and connection to drainage piping.
  - a. Nominal Size: **6 inches (2-mm)** high by approximately **0.9 inch (23 mm)** thick.
    - 1) Minimum In-Plane Flow: **2.4 gpm (9.1 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - b. Filter Fabric: Nonwoven geotextile made of PP or polyester fibers or combination of both. Flow rates range from **120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m)** when tested according to ASTM D 4491.
5. **Ring Fabric Drainage Conduits:** Drainage conduit with HDPE-rings-in-grid-pattern drainage core, for field-applied geotextile filter fabric. Include fittings for bends and connection to drainage piping.
  - a. Nominal Size: **18 inches (0.5 m)** high by **1 inch (25 mm)** thick.
    - 1) Minimum In-Plane Flow: **82 gpm (310 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - b. Nominal Size: **36 inches (1 m)** high by **1 inch (25 mm)** thick.
    - 1) Minimum In-Plane Flow: **164 gpm (621 L/min.)** at hydraulic gradient of 1.0 when tested according to ASTM D 4716.
  - c. Filter Fabric: Specified in Part 1.2 "Geotextile Filter Fabrics" Article.

#### C. Drainage Panels

1. **Molded-Sheet Drainage Panels:** Prefabricated geocomposite, **36 to 60 inches (915 to 1525 mm)** wide with drainage core faced with geotextile filter fabric.
  - a. **Drainage Core:** Three-dimensional, nonbiodegradable, molded PP.
    - 1) Minimum Compressive Strength: **10,000 lbf/sq. ft. (479 kPa) OR 15,000 lbf/sq. ft. (718 kPa) OR 18,000 lbf/sq. ft. (862 kPa) OR 21,000 lbf/sq. ft. (1005 kPa), as directed**, when tested according to ASTM D 1621.

- 2) Minimum In-Plane Flow Rate: **2.8 gpm/ft. (35 L/min. per m)** OR **7 gpm/ft. (87 L/min. per m)** OR **15 gpm/ft. (188 L/min. per m)**, **as directed**, of unit width at hydraulic gradient of 1.0 and compressive stress of **25 psig (172 kPa)** when tested according to ASTM D 4716.
- b. Filter Fabric: Nonwoven needle-punched geotextile, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with the following properties determined according to AASHTO M 288:
  - 1) Survivability: Class 1 OR 2 OR 3, **as directed**.
  - 2) Apparent Opening Size: **No. 40 (0.425-mm)** OR **No. 60 (0.25-mm)** OR **No. 70 (0.212-mm)**, **as directed**, sieve, maximum.
  - 3) Permittivity: 0.5 OR 0.2 OR 0.1, **as directed**, per second, minimum.
- c. Filter Fabric: Woven geotextile fabric, manufactured for subsurface drainage, made from polyolefins or polyesters; with elongation less than 50 percent; complying with the following properties determined according to AASHTO M 288:
  - 1) Survivability: Class 1 OR 2 OR 3, **as directed**.
  - 2) Apparent Opening Size: **No. 40 (0.425-mm)** OR **No. 60 (0.25-mm)** OR **No. 70 (0.212-mm)** OR **No. 30 (0.6-mm)**, **as directed**, sieve, maximum.
  - 3) Permittivity: 0.5 OR 0.2 OR 0.1 OR 0.02, **as directed**, per second, minimum.
- d. Film Backing: Polymeric film bonded to drainage core surface.
2. Mesh Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.
  - a. Drainage Core: Open-construction, resilient, approximately **0.4-inch- (10.2-mm-)** thick, plastic-filament mesh.
    - 1) Minimum In-Plane Flow Rate: **2.4 gpm/ft. (30 L/min. per m)** of unit width at hydraulic gradient of 1.0 and normal pressure of **25 psig (172 kPa)** when tested according to ASTM D 4716.
  - b. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from **120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m)** when tested according to ASTM D 4491.
3. Net Fabric Drainage Panels: Prefabricated geocomposite with drainage core faced with geotextile filter fabric.
  - a. Drainage Core: 3-dimensional, PE nonwoven-strand geonet, approximately **0.25-inch- (6-mm-)** thick.
    - 1) Minimum In-Plane Flow Rate: **2.4 gpm/ft. (30 L/min. per m)** OR **5 gpm/ft. (62 L/min. per m)**, **as directed**, of unit width at hydraulic gradient of 1.0 and normal pressure of **25 psig (172 kPa)** when tested according to ASTM D 4716.
  - b. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from **120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m)** when tested according to ASTM D 4491.
4. Ring Fabric Drainage Panels: Drainage-core panel for field application of geotextile filter fabric.
  - a. Drainage Core: 3-dimensional, HDPE rings in grid pattern, approximately **1 inch (25 mm)** thick.
    - 1) Minimum In-Plane Flow Rate: **40 gpm/ft. (500 L/min. per m)** of unit width at hydraulic gradient of 1.0 and normal pressure of **25 psig (172 kPa)** when tested according to ASTM D 4716.
5. Fabric-Covered Insulated Drainage Panels: Extruded PS board insulation complying with ASTM C 578; fabricated with shiplap OR tongue-and-groove, **as directed**, edges and with one side having grooved drainage channels; unfaced OR ; faced with geotextile filter fabric, **as directed**.
  - a. Type IV, **1.6-lb/cu. ft. (26-kg/cu. m)** minimum density and **25-psig (172-kPa)** minimum compressive strength.
  - b. Type VI, **1.8-lb/cu. ft. (29-kg/cu. m)** minimum density and **40-psig (276-kPa)** minimum compressive strength.
  - c. Minimum In-Plane Flow Rate: **9 gpm/ft. (112 L/min. per m)** of unit width when tested according to ASTM D 4716.

- d. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.
- 6. Noncovered Insulated Drainage Panels: Extruded PS board insulation complying with ASTM C 578; fabricated with rabbeted edges and with one side having ribbed drainage channels.
  - a. Type VI, 1.8-lb/cu. ft. (29-kg/cu. m) minimum density and 40-psig (276-kPa) minimum compressive strength.
  - b. Type VII, 2.2-lb/cu. ft. (35-kg/cu. m) minimum density and 60-psig (414-kPa) minimum compressive strength.
  - c. Minimum In-Plane Flow Rate: 9 gpm/ft. (112 L/min. per m) of unit width when tested according to ASTM D 4716.
- 7. Expanded PS Insulated Drainage Panels: PS bead board insulation; panels are 4 inches (102 mm) thick by 48 inches (1220 mm) wide and faced with geotextile filter fabric.
  - a. Density: 2 lb/cu. ft. (32 kg/cu. m).
  - b. Compressive Strength: 800 lbf/sq. ft. (38 kPa).
  - c. Minimum In-Plane Flow Rate: 3 gpm/ft. (37 L/min. per m) of unit width when tested according to ASTM D 4716.
  - d. Filter Fabric: Nonwoven geotextile of PP or polyester fibers or combination of both. Flow rates range from 120 to 200 gpm/sq. ft. (81 to 136 L/s per sq. m) when tested according to ASTM D 4491.

D. Soil Materials

- 1. Soil materials are specified in Division 31 Section "Earth Moving".

E. Waterproofing Felts

- 1. Material: Comply with ASTM D 226, Type I, asphalt **OR** ASTM D 227, coal-tar, **as directed**, -saturated organic felt.

F. Geotextile Filter Fabrics

- 1. Description: Fabric of PP or polyester fibers or combination of both, with flow rate range from 110 to 330 gpm/sq. ft. (4480 to 13 440 L/min. per sq. m) when tested according to ASTM D 4491.
  - a. Structure Type: Nonwoven, needle-punched continuous filament.
    - 1) Survivability: AASHTO **M 288 Class 2**.
    - 2) Style(s): Flat **OR** sock, **as directed**.

### 1.3 EXECUTION

A. Earthwork

- 1. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Foundation Drainage Installation

- 1. Place impervious fill material on subgrade adjacent to bottom of footing after concrete footing forms have been removed. Place and compact impervious fill to dimensions indicated, but not less than 6 inches (150 mm) deep and 12 inches (300 mm) wide.
- 2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
- 3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than 4 inches (100 mm).
- 4. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
- 5. Install drainage piping as indicated in Article 1.3 "Piping Installation" for foundation subdrainage.
- 6. Add drainage course to width of at least 6 inches (150 mm) on side away from wall and to top of pipe to perform tests.
- 7. After satisfactory testing, cover drainage piping to width of at least 6 inches (150 mm) on side away from footing and above top of pipe to within 12 inches (300 mm) of finish grade.

8. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
  9. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed**, over top of drainage course, overlapping edges at least **4 inches (100 mm)**.
  10. Install drainage panels on foundation walls as follows:
    - a. Coordinate placement with other drainage materials.
    - b. Lay perforated drainage pipe at base of footing. Install as indicated in Article 1.3 "Piping Installation."
    - c. Separate **4 inches (100 mm)** of fabric at beginning of roll and cut away **4 inches (100 mm)** of core. Wrap fabric around end of remaining core.
    - d. Attach panels to wall beginning at subdrainage pipe. Place and secure molded-sheet drainage panels, with geotextile facing away from wall.
  11. Place backfill material over compacted drainage course. Place material in loose-depth layers not exceeding **6 inches (150 mm)**. Thoroughly compact each layer. Final backfill to finish elevations and slope away from building.
- C. Underslab Drainage Installation
1. Excavate for underslab drainage system after subgrade material has been compacted but before drainage course has been placed. Include horizontal distance of at least **6 inches (150 mm)** between drainage pipe and trench walls. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
  2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
  3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than **4 inches (100 mm)**.
  4. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
  5. Install drainage piping as indicated in Part 1.3 "Piping Installation" Article for underslab subdrainage.
  6. Add drainage course to width of at least **6 inches (150 mm)** on side away from wall and to top of pipe to perform tests.
  7. After satisfactory testing, cover drainage piping with drainage course to elevation of bottom of slab, and compact and wrap top of drainage course with flat-style geotextile filter fabric.
  8. Install horizontal drainage panels as follows:
    - a. Coordinate placement with other drainage materials.
    - b. Lay perforated drainage pipe at inside edge of footings.
    - c. Place drainage panel over drainage pipe with core side up. Peel back fabric and wrap fabric around pipe. Locate top of core at bottom elevation of floor slab.
    - d. Butt additional panels against other installed panels. If panels have plastic flanges, overlap installed panel with flange.
- D. Retaining-Wall Drainage Installation
1. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
  2. Place supporting layer of drainage course over compacted subgrade to compacted depth of not less than **4 inches (100 mm)**.
  3. Encase pipe with sock-style geotextile filter fabric before installing pipe. Connect sock sections with adhesive or tape.
  4. Install drainage piping as indicated in Article 1.3 "Piping Installation" for retaining-wall subdrainage.
  5. Add drainage course to width of at least **6 inches (150 mm)** on side away from wall and to top of pipe to perform tests.
  6. After satisfactory testing, cover drainage piping to width of at least **6 inches (150 mm)** on side away from footing and above top of pipe to within **12 inches (300 mm)** of finish grade.
  7. Place drainage course in layers not exceeding **3 inches (75 mm)** in loose depth; compact each layer placed and wrap top of drainage course with flat-style geotextile filter fabric.
  8. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed**, over top of drainage course, overlapping edges at least **4 inches (100 mm)**.
  9. Install drainage panels on walls as follows:

- a. Coordinate placement with other drainage materials.
  - b. Lay perforated drainage pipe at base of footing as described elsewhere in this Specification. Do not install aggregate.
  - c. If weep holes are used instead of drainage pipe, cut **1/2-inch- (13-mm-)** diameter holes on core side at weep-hole locations. Do not cut fabric.
  - d. Mark horizontal chalk line on wall at a point **6 inches (150 mm)** less than panel width above footing bottom. Before marking wall, subtract footing width.
  - e. Separate **4 inches (100 mm)** of fabric at beginning of roll and cut away **4 inches (100 mm)** of core. Wrap fabric around end of remaining core.
  - f. Attach panel to wall at horizontal mark and at beginning of wall corner. Place core side of panel against wall. Use concrete nails with washers through product. Place nails from **2 to 6 inches (50 to 150 mm)** below top of panel, approximately **48 inches (1200 mm)** apart. Construction adhesives, metal stick pins, or double-sided tape may be used instead of nails. Do not penetrate waterproofing. Before using adhesives, discuss with waterproofing manufacturer.
  - g. If another panel is required on same row, cut away **4 inches (100 mm)** of installed panel core and wrap fabric over new panel.
  - h. If additional rows of panel are required, overlap lower panel with **4 inches (100 mm)** of fabric.
  - i. Cut panel as necessary to keep top **12 inches (300 mm)** below finish grade.
  - j. For inside corners, bend panel. For outside corners, cut core to provide **3 inches (75 mm)** for overlap.
10. Fill to Grade: Place satisfactory soil fill material over compacted drainage course. Place material in loose-depth layers not exceeding **6 inches (150 mm)**. Thoroughly compact each layer. Fill to finish grade.

E. Landscaping Drainage Installation

1. Provide trench width to allow installation of drainage conduit. Grade bottom of trench excavations to required slope, and compact to firm, solid bed for drainage system.
2. Lay flat-style geotextile filter fabric in trench and overlap trench sides.
3. Place supporting layer of drainage course over compacted subgrade and geotextile filter fabric, to compacted depth of not less than **4 inches (100 mm)**.
4. Install drainage conduits as indicated in Article 1.3 "Piping Installation" for landscaping subdrainage with horizontal distance of at least **6 inches (150 mm)** between conduit and trench walls. Wrap drainage conduits without integral geotextile filter fabric with flat-style geotextile filter fabric before installation. Connect fabric sections with adhesive or tape.
5. Add drainage course to top of drainage conduits.
6. After satisfactory testing, cover drainage conduit to within **12 inches (300 mm)** of finish grade.
7. Install drainage course and wrap top of drainage course with flat-style geotextile filter fabric.
8. Place layer of flat-style geotextile filter fabric **OR** waterproofing felt, **as directed**, over top of drainage course, overlapping edges at least **4 inches (100 mm)**.
9. Fill to Grade: Place satisfactory soil fill material over drainage course. Place material in loose-depth layers not exceeding **6 inches (150 mm)**. Thoroughly compact each layer. Fill to finish grade.

F. Piping Installation

1. Install piping beginning at low points of system, true to grades and alignment indicated, with unbroken continuity of invert. Bed piping with full bearing in filtering material. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions and other requirements indicated.
  - a. Foundation Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of **36 inches (915 mm)**, unless otherwise indicated.
  - b. Underslab Subdrainage: Install piping level.
  - c. Plaza Deck Subdrainage: Install piping level.



- d. Retaining-Wall Subdrainage: When water discharges at end of wall into stormwater piping system, install piping level and with a minimum cover of **36 inches (915 mm)**, unless otherwise indicated.
  - e. Landscaping Subdrainage: Install piping pitched down in direction of flow, at a minimum slope of 0.5 percent and with a minimum cover of **36 inches (915 mm)**, unless otherwise indicated.
  - f. Lay perforated pipe with perforations down.
  - g. Excavate recesses in trench bottom for bell ends of pipe. Lay pipe with bells facing upslope and with spigot end entered fully into adjacent bell.
  2. Use increasers, reducers, and couplings made for different sizes or materials of pipes and fittings being connected. Reduction of pipe size in direction of flow is prohibited.
  3. Install thermoplastic piping according to ASTM D 2321.
- G. Pipe Joint Construction
1. Join perforated PE pipe and fittings with couplings according to ASTM D 3212 with loose banded, coupled, or push-on joints.
  2. Join perforated PVC sewer pipe and fittings according to ASTM D 3212 with loose bell-and-spigot, push-on joints.
  3. Special Pipe Couplings: Join piping made of different materials and dimensions with special couplings made for this application. Use couplings that are compatible with and fit materials and dimensions of both pipes.
- 1.4 Backwater Valve Installation
1. Comply with requirements for backwater valves specified in Division 2 Section "Storm Drainage."
  2. Install horizontal backwater valves in header piping downstream from perforated subdrainage piping.
  3. Install horizontal backwater valves in piping in manholes or pits where indicated.
- B. Cleanout Installation
1. Comply with requirements for cleanouts specified in Division 2 Section "Storm Drainage."
  2. Cleanouts for Foundation, Retaining-Wall, and Landscaping Subdrainage:
    - a. Install cleanouts from piping to grade. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
    - b. In vehicular-traffic areas, use **NPS 4 (DN 100)** cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, **18 by 18 by 12 inches (450 by 450 by 300 mm)** in depth. Set top of cleanout flush with grade. Cast-iron pipe may also be used for cleanouts in nonvehicular-traffic areas.
    - c. In nonvehicular-traffic areas, use **NPS 4 (DN 100)** cast-iron **OR PVC, as directed**, pipe and fittings for piping branch fittings and riser extensions to cleanout. Set cleanout frames and covers in a cast-in-place concrete anchor, **12 by 12 by 4 inches (300 by 300 by 100 mm)** in depth. Set top of cleanout plug **1 inch (25 mm)** above grade.
  3. Cleanouts for Underslab Subdrainage:
    - a. Install cleanouts and riser extensions from piping to top of slab. Locate cleanouts at beginning of piping run and at changes in direction. Install fittings so cleanouts open in direction of flow in piping.
    - b. Use **NPS 4 (DN 100)** cast-iron soil pipe and fittings for piping branch fittings and riser extensions to cleanout flush with top of slab.
- C. Connections
1. Comply with requirements for piping specified in Division 2 Section "Storm Drainage." Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Connect low elevations of subdrainage system to building's solid-wall-piping storm drainage system.

3. Where required, connect low elevations of foundation **OR** Underslab, **as directed**, subdrainage to stormwater sump pumps.

D. Identification

1. Arrange for installation of green warning tapes directly over piping. Comply with requirements for underground warning tapes specified in specified in Division 31 Section "Earth Moving".
  - a. Install PE warning tape or detectable warning tape over ferrous piping.
  - b. Install detectable warning tape over nonferrous piping and over edges of underground structures.

E. Field Quality Control

1. Tests and Inspections:
  - a. After installing drainage course to top of piping, test drain piping with water to ensure free flow before backfilling.
  - b. Remove obstructions, replace damaged components, and repeat test until results are satisfactory.
2. Drain piping will be considered defective if it does not pass tests and inspections.
3. Prepare test and inspection reports.

F. Cleaning

1. Clear interior of installed piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of each day or when work stops.

END OF SECTION 31 05 13 00



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Task	Specification	Specification Description
31 05 13 00	31 01 20 00	Earthwork
31 05 16 00	31 01 20 00	Earthwork
31 05 16 00	31 05 13 00	Subdrainage

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## SECTION 31 11 00 00 - SITE CLEARING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for site clearing. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Protecting existing vegetation to remain.
  - b. Removing existing vegetation.
  - c. Clearing and grubbing.
  - d. Stripping and stockpiling topsoil.
  - e. Removing above- and below-grade site improvements.
  - f. Disconnecting, capping or sealing, and removing site utilities **OR** abandoning site utilities in place, **as directed**.
  - g. Temporary erosion- and sedimentation-control measures.

#### C. Definitions

1. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.  
**OR**  
Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.
2. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow.  
**OR**  
Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than **2 inches (50 mm)** in diameter; and free of subsoil and weeds, roots, toxic materials, or other nonsoil materials.
3. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.  
**OR**  
Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings **OR** defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated, **as directed**.
4. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

#### D. Material Ownership

1. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain the Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

#### E. Submittals

1. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.
  - a. Use sufficiently detailed photographs or videotape.

- b. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.
2. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

F. Quality Assurance

1. Preinstallation Conference: Conduct conference at Project site.

G. Project Conditions

1. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.
  - a. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction.
  - b. Provide alternate routes around closed or obstructed traffic ways if required by the Owner or authorities having jurisdiction.
2. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining the Owner's property will be obtained by the Owner before award of Contract.
  - a. Do not proceed with work on adjoining property until directed by the Owner.
3. Salvable Improvements: Carefully remove items indicated to be salvaged and store on the Owner's premises where indicated.
4. Utility Locator Service: Notify utility locator service **OR** Miss Utility **OR** Call Before You Dig **OR** Dig Safe System **OR** One Call, **as directed**, for area where Project is located before site clearing.
5. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.
6. The following practices are prohibited within protection zones:
  - a. Storage of construction materials, debris, or excavated material.
  - b. Parking vehicles or equipment.
  - c. Foot traffic.
  - d. Erection of sheds or structures.
  - e. Impoundment of water.
  - f. Excavation or other digging unless otherwise indicated.
  - g. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
7. Do not direct vehicle or equipment exhaust towards protection zones.
8. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.
9. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

## 1.2 PRODUCTS

A. Materials

1. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Division 31 Section "Earth Moving".
  - a. If soil backfill is required in below-grade areas after site clearing, obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.
2. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer complying with MPI #79, Alkyd Anticorrosive Metal Primer **OR** SSPC-Paint 20 or SSPC-Paint 29 zinc-rich coating, **as directed**.
  - a. Use coating with a VOC content of **420 g/L (3.5 lb/gal.)** or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

## 1.3 EXECUTION

A. Preparation

1. Protect and maintain benchmarks and survey control points from disturbance during construction.
  2. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Flag **OR** Wrap a 1-inch (25-mm) blue vinyl tie tape flag around, **as directed**, each tree trunk at 54 inches (1372 mm) above the ground.
  3. Protect existing site improvements to remain from damage during construction.
    - a. Restore damaged improvements to their original condition, as acceptable to the Owner.
- B. Temporary Erosion And Sedimentation Control
1. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.
  2. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
  3. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
  4. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.
- C. Tree And Plant Protection
1. General: Protect trees and plants remaining on-site according to requirements in Division 01 Section "Temporary Tree And Plant Protection".
  2. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by the Owner.
- D. Existing Utilities
1. the Owner will arrange for disconnecting and sealing indicated utilities that serve existing structures before site clearing, when requested by Contractor.  
**OR**  
Verify that utilities have been disconnected and capped before proceeding with site clearing.
  2. Locate, identify, disconnect, and seal or cap utilities indicated to be removed.
    - a. Arrange with utility companies to shut off indicated utilities.  
**OR**  
the Owner will arrange to shut off indicated utilities when requested by Contractor.
  3. Locate, identify, and disconnect utilities indicated to be abandoned in place.
  4. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
    - a. Notify the Owner not less than two days in advance of proposed utility interruptions.
    - b. Do not proceed with utility interruptions without the Owner's written permission.
  5. Excavate for and remove underground utilities indicated to be removed.  
**OR**  
Removal of underground utilities is included in Division 21 OR Division 22 OR Division 23 OR Division 26 OR Division 28.
- E. Clearing And Grubbing
1. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.
    - a. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
    - b. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches (450 mm) below exposed subgrade.
    - c. Use only hand methods for grubbing within protection zones.
    - d. Chip removed tree branches and stockpile in areas approved by the Owner **OR** dispose of off-site, **as directed**.
  2. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

- a. Place fill material in horizontal layers not exceeding a loose depth of **8 inches (200 mm)**, and compact each layer to a density equal to adjacent original ground.

F. Topsoil Stripping

1. Remove sod and grass before stripping topsoil.
2. Strip topsoil to depth indicated on Drawings **OR** to depth of **6 inches (150 mm)**, **as directed**, in a manner to prevent intermingling with underlying subsoil or other waste materials.
  - a. Remove subsoil and nonsoil materials from topsoil, including clay lumps, gravel, and other objects more than **2 inches (50 mm)** in diameter; trash, debris, weeds, roots, and other waste materials.
3. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.
  - a. Limit height of topsoil stockpiles to **72 inches (1800 mm)**.
  - b. Do not stockpile topsoil within protection zones.
  - c. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
  - d. Stockpile surplus topsoil to allow for respreading deeper topsoil.

G. Site Improvements

1. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.
2. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.
  - a. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
  - b. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

H. Disposal Of Surplus And Waste Materials

1. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off the Owner's property.
2. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with other Project work.

END OF SECTION 31 11 00 00

## SECTION 31 13 13 00 - TREE PROTECTION AND TRIMMING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for tree protection and trimming. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes general protection and pruning of existing trees and plants that are affected by execution of the Work, whether temporary or permanent construction.

#### C. Definitions

1. Caliper: Diameter of a trunk measured by a diameter tape or the average of the smallest and largest diameters at **6 inches (150 mm)** above the ground for trees up to, and including, **4-inch (100-mm)** size; and **12 inches (300 mm)** above the ground for trees larger than **4-inch (100-mm)** size.
2. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.
3. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and indicated on Drawings **OR** defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated, **as directed**.
4. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Tree Pruning Schedule: Written schedule detailing scope and extent of pruning of trees to remain that interfere with or are affected by construction.
3. Qualification Data: For qualified arborist and tree service firm.
4. Certification: From arborist, certifying that trees indicated to remain have been protected during construction according to recognized standards and that trees were promptly and properly treated and repaired when damaged.
5. Maintenance Recommendations: From arborist, for care and protection of trees affected by construction during and after completing the Work.
6. Existing Conditions: Documentation of existing trees and plantings indicated to remain, which establishes preconstruction conditions that might be misconstrued as damage caused by construction activities.
  - a. Use sufficiently detailed photographs or videotape.
  - b. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

#### E. Quality Assurance

1. Arborist Qualifications: Certified Arborist as certified by ISA **OR** Certified Arborist-Municipal Specialist as certified by ISA **OR** Licensed arborist in jurisdiction where Project is located **OR** Current member of ASCA **OR** Registered Consulting Arborist as designated by ASCA, **as directed**.
2. Tree Service Firm Qualifications: An experienced tree service firm that has successfully completed temporary tree and plant protection work similar to that required for this Project and that will assign an experienced, qualified arborist to Project site during execution of the Work.
3. Preinstallation Conference: Conduct conference at Project site.

#### F. Project Conditions

1. The following practices are prohibited within protection zones:
  - a. Storage of construction materials, debris, or excavated material.
  - b. Parking vehicles or equipment.
  - c. Foot traffic.
  - d. Erection of sheds or structures.
  - e. Impoundment of water.
  - f. Excavation or other digging unless otherwise indicated.
  - g. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.
2. Do not direct vehicle or equipment exhaust toward protection zones.
3. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones and organic mulch.

## 1.2 PRODUCTS

### A. Materials

1. Topsoil: Natural or cultivated top layer of the soil profile or manufactured topsoil; containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than **1 inch (25 mm)** in diameter; and free of weeds, roots, and toxic and other nonsoil materials.
  - a. Obtain topsoil only from well-drained sites where topsoil is **4 inches (100 mm)** deep or more; do not obtain from bogs or marshes.

**OR**

Topsoil: Stockpiled topsoil from location shown on Drawings **OR** Imported or manufactured topsoil complying with ASTM D 5268, **as directed**.
2. Organic Mulch: Free from deleterious materials and suitable as a top dressing for trees and shrubs, consisting of one of the following:
  - a. Type: Shredded hardwood **OR** Ground or shredded bark **OR** Wood and bark chips, **as directed**.
  - b. Size Range: **3 inches (76 mm)** maximum, **1/2 inch (13 mm)** minimum.
3. Protection-Zone Fencing: Fencing fixed in position and meeting one of the following requirements, **as directed**. Previously used materials may be used when approved by the Owner.
  - a. Chain-Link Protection-Zone Fencing: Galvanized-steel **OR** Polymer-coated steel **OR** Polymer-coated galvanized-steel, **as directed**, fencing fabricated from minimum **2-inch (50-mm)** opening, **0.148-inch- (3.76-mm-)** diameter wire chain-link fabric; with pipe posts, minimum **2-3/8-inch- (60-mm-)** OD line posts, and **2-7/8-inch- (73-mm-)** OD corner and pull posts; with **1-5/8-inch- (42-mm-)** OD top rails **OR** with **0.177-inch- (4.5-mm-)** diameter top tension wire, **as directed**, and **0.177-inch- (4.5-mm-)** diameter bottom tension wire; with tie wires, hog ring ties, and other accessories for a complete fence system.
    - 1) Height: **4 feet (1.2 m) OR 6 feet (1.8 m) OR 8 feet (2.4 m)**, **as directed**.
    - 2) Polymer-Coating Color (if polymer coating is required): Dark green **OR** Olive green **OR** Brown **OR** Black, **as directed**.
  - b. Plywood Protection-Zone Fencing: Plywood framed with four **2-by-4-inch (50-by-100-mm)** rails, with **4-by-4-inch (100-by-100-mm)** preservative-treated wood posts spaced not more than **8 feet (2.4 m)** apart.
    - 1) Height: **4 feet (1.2 m) OR 6 feet (1.8 m)**, **as directed**.
    - 2) Plywood and Lumber: Comply with requirements in Division 06 Section "Rough Carpentry" **OR** Division 06 Section "Miscellaneous Rough Carpentry", **as directed**.
  - c. Wood Protection-Zone Fencing: Constructed of two **2-by-4-inch (50-by-100-mm)** horizontal rails, with **4-by-4-inch (100-by-100-mm)** preservative-treated wood posts spaced not more than **8 feet (2.4 m)** apart, and lower rail set halfway between top rail and ground.
    - 1) Height: **4 feet (1.2 m)**.



- 2) Lumber: Comply with requirements in Division 06 Section "Rough Carpentry" **OR** Division 06 Section "Miscellaneous Rough Carpentry", **as directed**.
- d. Plastic Protection-Zone Fencing: Plastic construction fencing constructed of high-density extruded and stretched polyethylene fabric with **2-inch (50-mm)** maximum opening in pattern and weighing a minimum of **0.4 lb/ft. (0.6 kg/m)**; remaining flexible from **minus 60 to plus 200 deg F (minus 16 to plus 93 deg C)**; inert to most chemicals and acids; minimum tensile yield strength of **2000 psi (13.8 MPa)** and ultimate tensile strength of **2680 psi (18.5 MPa)**; secured with plastic bands or galvanized-steel or stainless-steel wire ties; and supported by tubular or T-shape galvanized-steel posts spaced not more than **8 feet (2.4 m)** apart.
  - 1) Height: **4 feet (1.2 m)**.
  - 2) Color: High-visibility orange, nonfading.
- e. Gates: Single **OR** Double, **as directed**, swing access gates matching material and appearance of fencing, to allow for maintenance activities within protection zones; leaf width **24 inches (610 mm) OR 36 inches (914 mm) OR** As indicated, **as directed**.
4. Protection-Zone Signage: Shop-fabricated, rigid plastic or metal sheet with attachment holes prepunched and reinforced; legibly printed with nonfading lettering and as follows:
  - a. Size and Text: As shown on Drawings.
  - b. Lettering: **3-inch- (75-mm-)** high minimum, white **OR** black, **as directed**, characters on white **OR** red, **as directed**, background.

### 1.3 EXECUTION

#### A. Examination

1. Erosion and Sedimentation Control: Examine the site to verify that temporary erosion- and sedimentation-control measures are in place. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
2. For the record, prepare written report, endorsed by arborist, listing conditions detrimental to tree and plant protection.

#### B. Preparation

1. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Flag **OR** Tie a **1-inch (25-mm)** blue-vinyl tape around, **as directed**, each tree trunk at **54 inches (1372 mm)** above the ground.
2. Protect tree root systems from damage caused by runoff or spillage of noxious materials while mixing, placing, or storing construction materials. Protect root systems from ponding, eroding, or excessive wetting caused by dewatering operations.
3. Tree-Protection Zones: Mulch areas inside tree-protection zones and other areas indicated.
  - a. Apply **4-inch (100-mm) OR 6-inch (150-mm)**, **as directed**, average thickness of organic mulch. Do not place mulch within **6 inches (150 mm)** of tree trunks.

#### C. Tree- And Plant-Protection Zones

1. Protection-Zone Fencing: Install protection-zone fencing along edges of protection zones before materials or equipment are brought on the site and construction operations begin in a manner that will prevent people and animals from easily entering protected area except by entrance gates. Construct fencing so as not to obstruct safe passage or visibility at vehicle intersections where fencing is located adjacent to pedestrian walkways or in close proximity to street intersections, drives, or other vehicular circulation.
  - a. Chain-Link Fencing: Install to comply with ASTM F 567 and with manufacturer's written instructions.
  - b. Posts: Set or drive posts into ground one-third the total height of the fence without concrete footings. Where a post is located on existing paving or concrete to remain, provide appropriate means of post support acceptable to the Owner.
  - c. Access Gates: Install where indicated; adjust to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption,



or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

2. Protection-Zone Signage: Install protection-zone signage in visibly prominent locations in a manner approved by the Owner. Install one sign spaced approximately every **20 feet (6 m) OR 35 feet (10.5 m) OR 50 feet (15 m)**, **as directed**, on protection-zone fencing, but no fewer than four signs with each facing a different direction.
3. Maintain protection zones free of weeds and trash.
4. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by the Owner.
5. Maintain protection-zone fencing and signage in good condition as acceptable to the Owner and remove when construction operations are complete and equipment has been removed from the site.
  - a. Do not remove protection-zone fencing, even temporarily, to allow deliveries or equipment access through the protection zone.
  - b. Temporary access is permitted subject to preapproval in writing by arborist if a root buffer effective against soil compaction is constructed as directed by arborist. Maintain root buffer so long as access is permitted.

#### D. Excavation

1. General: Excavate at edge of protection zones and for trenches indicated within protection zones according to requirements in Division 31 Section "Earth Moving".
2. Trenching near Trees: Where utility trenches are required within protection zones, hand excavate under or around tree roots or tunnel under the roots by drilling, auger boring, or pipe jacking. Do not cut main lateral tree roots or taproots; cut only smaller roots that interfere with installation of utilities. Cut roots as required for root pruning.
3. Redirect roots in backfill areas where possible. If encountering large, main lateral roots, expose roots beyond excavation limits as required to bend and redirect them without breaking. If encountered immediately adjacent to location of new construction and redirection is not practical, cut roots approximately **3 inches (75 mm)** back from new construction and as required for root pruning.
4. Do not allow exposed roots to dry out before placing permanent backfill. Provide temporary earth cover or pack with peat moss and wrap with burlap. Water and maintain in a moist condition. Temporarily support and protect roots from damage until they are permanently relocated and covered with soil.

#### E. Root Pruning

1. Prune roots that are affected by temporary and permanent construction. Prune roots as follows:
  - a. Cut roots manually by digging a trench and cutting exposed roots with sharp pruning instruments; do not break, tear, chop, or slant the cuts. Do not use a backhoe or other equipment that rips, tears, or pulls roots.
  - b. Cut Ends: Do not paint cut root ends **OR** Coat cut ends of roots more than **1-1/2 inches (38 mm)** in diameter with an emulsified asphalt or other coating formulated for use on damaged plant tissues and that is acceptable to arborist, **as directed**.
  - c. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
  - d. Cover exposed roots with burlap and water regularly.
  - e. Backfill as soon as possible according to requirements in Division 31 Section "Earth Moving".
2. Root Pruning at Edge of Protection Zone: Prune roots **12 inches (300 mm)** outside **OR 12 inches (300 mm)** inside **OR 6 inches (150 mm)** outside **OR 6 inches (150 mm)** inside **OR** flush with the edge, **as directed**, of the protection zone, by cleanly cutting all roots to the depth of the required excavation.
3. Root Pruning within Protection Zone: Clear and excavate by hand to the depth of the required excavation to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

- F. Crown Pruning
1. Prune branches that are affected by temporary and permanent construction. Prune branches as follows:
    - a. Prune trees to remain to compensate for root loss caused by damaging or cutting root system. Provide subsequent maintenance during Contract period as recommended by arborist.
    - b. Pruning Standards: Prune trees according to ANSI A300 (Part 1) and the following:
      - 1) Type of Pruning: Cleaning **OR** Thinning **OR** Raising **OR** Reduction, **as directed**.
      - 2) Specialty Pruning: Restoration **OR** Vista **OR** Palm **OR** Utility, **as directed**.
    - c. Cut branches with sharp pruning instruments; do not break or chop.
    - d. Do not apply pruning paint to wounds.
  2. Chip removed branches and spread over areas identified by the Owner **OR** stockpile in areas approved by the Owner **OR** dispose of off-site, **as directed**.
- G. Regrading
1. Lowering Grade: Where new finish grade is indicated below existing grade around trees, slope grade beyond the protection zone. Maintain existing grades within the protection zone.  
**OR**  
Lowering Grade within Protection Zone: Where new finish grade is indicated below existing grade around trees, slope grade away from trees as recommended by arborist unless otherwise indicated.
    - a. Root Pruning: Prune tree roots exposed by lowering the grade. Do not cut main lateral roots or taproots; cut only smaller roots. Cut roots as required for root pruning.
  2. Raising Grade: Where new finish grade is indicated above existing grade around trees, slope grade beyond the protection zone. Maintain existing grades within the protection zone.  
**OR**  
Minor Fill within Protection Zone: Where existing grade is **2 inches (50 mm)** or less below elevation of finish grade, fill with topsoil. Place topsoil in a single uncompacted layer and hand grade to required finish elevations.
- H. Field Quality Control
1. Inspections: Engage a qualified arborist to direct plant-protection measures in the vicinity of trees, shrubs, and other vegetation indicated to remain and to prepare inspection reports.
- I. Repair And Replacement
1. General: Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by the Owner.
    - a. Submit details of proposed root cutting and tree and shrub repairs.
    - b. Have arborist perform the root cutting, branch pruning, and damage repair of trees and shrubs.
    - c. Treat damaged trunks, limbs, and roots according to arborist's written instructions.
    - d. Perform repairs within 24 hours.
    - e. Replace vegetation that cannot be repaired and restored to full-growth status, as determined by the Owner.
  2. Trees: Remove and replace trees indicated to remain that are more than 25 **OR** 66, **as directed**, percent dead or in an unhealthy condition before the end of the corrections period or are damaged during construction operations that the Owner determines are incapable of restoring to normal growth pattern.
    - a. Provide new trees of same size and species as those being replaced for each tree that measures **6 inches (150 mm) OR 4 inches (100 mm)**, **as directed**, or smaller in caliper size.  
**OR**  
Provide one **OR** two, **as directed**, new tree(s) of **6-inch (150-mm) OR 4-inch (100-mm)**, **as directed**, caliper size for each tree being replaced that measures more than **6 inches (150 mm) OR 4 inches (100 mm)**, **as directed**, in caliper size.
      - 1) Species: Species selected by the Owner.



- b. Plant and maintain new trees as specified in Division 32 Section "Plants".
- 3. Soil Aeration: Where directed by the Owner, aerate surface soil compacted during construction. Aerate **10 feet (3 m)** beyond drip line and no closer than **36 inches (900 mm)** to tree trunk. Drill **2-inch- (50-mm-)** diameter holes a minimum of **12 inches (300 mm)** deep at **24 inches (600 mm)** o.c. Backfill holes with an equal mix of augered soil and sand.
- J. Disposal Of Surplus And Waste Materials
  - 1. Disposal: Remove excess excavated material, displaced trees, trash and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 13 13 00

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Task	Specification	Specification Description
31 13 13 00	31 11 00 00	Site Clearing
31 13 16 00	31 11 00 00	Site Clearing
31 13 16 00	31 13 13 00	Tree Protection And Trimming

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## SECTION 31 23 16 13 - EXCAVATION SUPPORT AND PROTECTION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for excavation support and protection. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Performance Requirements

1. Design, **as directed**, furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.
  - a. Delegated Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
  - b. Prevent surface water from entering excavations by grading, dikes, or other means.
  - c. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
  - d. Monitor vibrations, settlements, and movements.

#### C. Submittals

1. Shop Drawings: For excavation support and protection system.
2. Delegated-Design Submittal: For excavation support and protection system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

#### D. Quality Assurance

1. Preinstallation Conference: Conduct conference at Project site.

#### E. Project Conditions

1. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed interruption of utility.
  - b. Do not proceed with interruption of utility without the Owner's written permission.
2. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
  - a. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify the Owner if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

### 1.2 PRODUCTS

#### A. Materials

1. General: Provide materials that are either new or in serviceable condition.
2. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.
3. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.



- a. Corners: Site-fabricated mechanical interlock **OR** Roll-formed corner shape with continuous interlock, **as directed**.
4. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application, **OR 3 inches (75 mm) OR 4 inches (100 mm), as directed**.
5. Shotcrete: Comply with Division 03 Section "Shotcrete" for shotcrete materials and mixes, reinforcement, and shotcrete application.
6. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.
7. Reinforcing Bars: ASTM A 615/A 615M, **Grade 60 (Grade 420)**, deformed.
8. Tiebacks: Steel bars, ASTM A 722/A 722M.
9. Tiebacks: Steel strand, ASTM A 416/A 416M.

### 1.3 EXECUTION

#### A. Preparation

1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.
  - a. Shore, support, and protect utilities encountered.
2. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
  - a. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
3. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.
4. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.
5. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

#### B. Soldier Piles And Lagging

1. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than **2 inches (50 mm)** from a horizontal line and not more than 1:120 out of vertical alignment.
2. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.
3. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

#### C. Sheet Piling

1. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to **60 inches (1500 mm)**. Accurately align exposed faces of sheet piling to vary not more than **2 inches (50 mm)** from a horizontal line and not more than 1:120 out of vertical alignment. Cut tops of sheet piling to uniform elevation at top of excavation.

#### D. Tiebacks

1. Tiebacks: Drill, install, grout, and tension tiebacks. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks.
  - a. Test loading shall be observed by a qualified professional engineer responsible for design of excavation support and protection system.

- b. Maintain tiebacks in place until permanent construction is able to withstand lateral soil and hydrostatic pressures.
- E. Bracing
  - 1. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.
    - a. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by the Owner.
    - b. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
    - c. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.
- F. Removal And Repairs
  - 1. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.
    - a. Remove excavation support and protection systems to a minimum depth of 48 inches (1200 mm) below overlaying construction and abandon remainder.
    - b. Fill voids immediately with approved backfill compacted to density specified in Division 31 Section "Earth Moving".
    - c. Repair or replace, as approved by the Owner, adjacent work damaged or displaced by removing excavation support and protection systems.
  - 2. Leave excavation support and protection systems permanently in place.

END OF SECTION 31 23 16 13



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Task	Specification	Specification Description
31 23 16 13	31 01 20 00	Earthwork

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## SECTION 31 23 16 26 - EMBANKMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the reuse of suitable excavated material or furnishing material at the Contractor's expense to construct embankments where and as required by the Owner.

#### B. Submittals

1. Preconstruction Submittals
  - a. Construction equipment list.
  - b. Contractor shall record Existing Conditions prior to starting work in accordance with the paragraph entitled, "Existing Conditions," of this section.
  - c. Location of Utilities
  - d. Location of Tests
  - e. Location of Inspection
  - f. Location of Approved Utilities
  - g. A protection plan verifying the Existing Utilities left in place.
2. Test Reports for Soil Test within three working days of test date. Soil test shall comply with paragraph entitled, "Quality Control Testing During Construction."
3. Certificates of compliance for Proposed Soil Materials shall be submitted in accordance with paragraph entitled, "Tests for Proposed Soil Materials."

#### C. Definitions

1. Soil Materials
  - a. Cohesionless soil materials include gravels, gravel-sand mixtures, sands, and gravelly sands. Moisture-density relations of compacted cohesionless soils when plotted on graphs will show straight lines or reverse-shaped moisture-density curves.
  - b. Cohesive soil materials include clayey and silty gravels, sand-clay mixtures, gravel-silt mixtures, clayey and silty sands, sand-silt mixtures, clays, silts, and very fine sands. Moisture density relations of compacted cohesive soils when plotted on graphs will show normal moisture-density curves.
2. Subgrade shall mean the top surface of a backfill or fill or the uppermost surface of an excavation, graded to conform to the required subgrade elevation and compacted to densities indicated.
3. Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure in AASHTO T 180, Method B or D.
4. Classified Excavation: Separate consideration will be given to the nature of the materials excavated, in accordance with the following designations and classifications.
  - a. Rock excavation shall include blasting, excavating, grading, and disposing of material classified as rock and shall include the satisfactory removal and disposition of boulders 1/2-cu yd (0.4 cu m) or more in volume; solid rock; rock material in ledges, bedded deposits, and unstratified masses which cannot be removed without systematic drilling and blasting; and conglomerate deposits that are so firmly cemented as to possess the characteristics of solid rock that is impossible to remove without systematic drilling and blasting. The removal of any concrete or masonry structures, except pavements, exceeding 1/2-cu yd (0.4 cu m) in volume that may be encountered in the work shall be included in this classification.
  - b. Common excavation shall include the satisfactory removal and disposition of materials not classified as rock excavation.
5. Unclassified Excavation: No consideration will be given to the nature of the materials, and all excavation will be designated as unclassified excavation.

#### D. Sampling And Testing



1. Soil Test and Inspection Service: Soil survey for satisfactory soil materials and samples of soil materials shall be furnished by the Contractor. A certified soil testing service approved by the Owner shall be provided by the Contractor. Testing shall include soil survey for satisfactory soil materials, sampling and testing soil materials proposed for use in the work, and field-testing facilities for quality control during construction period.
2. Tests for Proposed Soil Materials: Soil materials proposed for use in the work shall be tested. The materials shall be approved by the Owner prior to start of work as follows:

<u>MATERIAL</u>	<u>REQUIREMENT</u>	<u>TEST METHOD</u>	<u>NUMBER OF TESTS</u>
Satisfactory soil materials	Sampling	AASHTO T 2	One for each source of materials to determine conformance to definition of satisfactory soil materials; additional tests whenever there is any apparent change
	Preparation of samples	AASHTO T 87	
	Sieve analysis of fine and coarse aggregate	ASTM C 136	
	Mechanical analysis of soils	ASTM D 422	
	Liquid limit of Soils	ASTM D 4318	
	Plastic limit and plasticity index of soils	ASTM D 4318	
	Moisture-density relations of soil	AASHTO T 180, Method B or D	

3. Quality Control Testing During Construction: Soil Test on materials shall be performed during construction as follows:

<u>MATERIAL</u>	<u>REQUIREMENT</u>	<u>TEST METHOD</u>	<u>MATERIAL TESTED AND NUMBER OF TESTS</u>
Soil material-in-place after compaction	Density of soil-in-place	ASTM D 1556 Sand Cone Method or ASTM D 2922 Nuclear Method	At least three daily for each subgrade soil material, and for each layer of soil material; additional tests whenever there is any change in moisture

4. Field Testing Facilities at Subbase Mixing Plant: Field-testing facilities for the purpose of testing subbase course material at the mixing plant shall be provided by the Contractor's soil-testing service.
5. Reports: No soil material shall be used until soil test reports have been reviewed and approved.
6. Evaluation of Test Results
- Soil materials of any classification shall not have a moisture content at the time of compaction that would be classified as unsatisfactory soil materials in the paragraph entitled, "Definitions."
  - Results of density of soil-in-place tests shall be considered satisfactory if the average of any group of four consecutive density tests which may be selected is in each instance equal to or greater than the specified density, and if no density test has a value more than 2 percentage points below the specified density.

E. Use Of Explosives:

- Explosives shall not be used or brought to the project site without prior written approval. Such approval shall not be construed as relieving the Contractor of responsibility for injury to persons or for damage to property due to blasting operations. Blasting shall be performed by skilled personnel in accordance with governing authorities and as approved. Minimum safety requirements for blasting shall be in accordance with OSHA Regulations 29 CFR 1926, Subpart U.  
**OR**  
The use of explosives will not be permitted.

F. Protection Of Persons And Property

- Excavations shall be barricaded and posted with warning signs for the safety of persons. Warning lights shall be provided during hours of darkness.
- Structures, utilities, sidewalks, pavements, and other facilities immediately adjacent to excavations shall be protected against damage including settlement, lateral movement, undermining, and washout.
- Topsoil removal operations shall be conducted to ensure safety of persons and to prevent damage to existing structures and utilities, construction in progress, trees and vegetation to remain standing, and other property.

G. Construction Equipment List: Construction Equipment List for all major equipment to be used in this section shall be submitted to the Owner prior to start of work.

H. Existing Conditions

- Records of Existing Conditions shall be submitted by the Contractor prior to the start of work. The Contractor shall verify the existing conditions are correct as shown on the plans and described in the specifications. the Owner shall be notified immediately if any discrepancies are found.



2. Records of underground utilities, Location of Utilities, Location of Inspection, Location of Tests, and Location of Approved Utilities shall be submitted to the Owner prior to start of work.

## 1.2 PRODUCTS

### A. Materials

1. Satisfactory Materials shall mean AASHTO M 145 (ASTM D 3282), Soil Classification Groups A-1, A-2-4, A-2-5, and A-3.
2. Unsatisfactory Materials shall mean AASHTO M 145, Soil Classification Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7, peat and other highly organic soils, and soil materials of any classification that have a moisture content, at the time of compaction, beyond the range of 1 percentage point below and 3 percentage points above the optimum moisture content of the soil material as determined by moisture-density relations test.
3. Topsoil shall be any soil removed from the project site which consists of clay or sandy loam. The topsoil shall be reasonably free from subsoil, clay lumps, brush, objectionable weeds, and other litter, and shall be free from stones, stumps, roots, and other objectionable material larger than **2 in. (50 mm)** in any dimension.
4. Compost shall be yard trimmings or yard waste compost processed and graded according to state and local regulations.
5. Topsoil Blend: Where insufficient topsoil is removed from the project site for later reuse, the topsoil removed shall be stockpiled and blended with compost at the site to achieve the required volume.

## 1.3 EXECUTION

### A. Blasting:

1. Where explosives are used in rock excavation, the charges shall be so proportioned and placed that they will not loosen the rock outside the excavation lines indicated, or as specified. Contractor shall remove, at no additional cost, any material outside the authorized cross section that may be shattered or loosened by blasting.  
**OR**  
Blasting is not required or permitted.

- B. Conservation Of Topsoil: Topsoil shall be stripped to a depth of not less than **4 in. (100 mm)**; when stored it shall be kept separate from other excavated materials, free of roots, stones, and other undesirable materials. Where indicated, topsoil shall be removed without contamination with subsoil and spread on areas already graded and prepared for topsoil, or when so specified, topsoil shall be transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later or at locations indicated or specified by the Owner. Topsoil blend shall be used on all embankments when there is not enough topsoil available.

### C. Excavation

1. Excavations specified shall be done on either a classified or unclassified basis as directed by the Owner.
2. Contractor shall perform excavation of every type of material encountered by cutting accurately to the cross sections to the lines, grades, and elevations indicated. Grading shall be in conformity with the typical sections indicated and the tolerances specified in paragraph entitled, "Finishing."
3. Satisfactory excavated materials shall be transported to and placed in fill or embankment areas within the limits of the work. Unsatisfactory materials encountered within the limits of the work shall be excavated below grade and replaced with satisfactory materials as directed. Surplus satisfactory excavated material not required for fill or embankment shall be disposed in areas approved for surplus materials storage or designated waste areas. Unsatisfactory excavated material shall be disposed in designated waste or spoil areas. During construction, excavation

- and filling shall be performed in a manner and sequence that will provide proper drainage at all times. Material required for fill or embankment in excess of that produced by excavation within the grading limits shall be excavated from the borrow areas indicated or from other approved areas selected by the Owner.
4. **Excavation of Ditches, Gutters, and Channels:** Care shall be taken not to excavate ditches and gutters below grades shown. Excessive open-ditch or gutter excavation shall be backfilled with suitable materials to grades indicated at no additional cost. Materials excavated shall be disposed as indicated, except that in no case shall material be deposited less than **3 ft. (1 m)** from the edge of a ditch. Contractor shall maintain excavations free from debris until final acceptance of the work.
  5. **Excavation for Drainage Structures**
    - a. Dimensions and elevations of footings and foundation excavations indicated are only approximate and may be changed if necessary to ensure adequate foundation support. Trenches and foundation pits shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations. Rock or other hard foundation material shall be cleaned of loose debris and cut to a firm surface, either level, stepped, or serrated. Loose disintegrated rock and thin strata shall be removed. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before concrete or masonry is to be placed.
    - b. Where pile foundations are to be used, the excavation of each pit shall be stopped at an elevation **1 ft. (300 mm)** above the base of the footing, as specified, before piles are driven. After pile driving has been completed, loose and displaced material shall be removed and excavation completed, leaving a smooth, solid, undisturbed surface to receive concrete or masonry.
  6. **Protection or Removal of Utility Lines:** Existing Utilities that are indicated to be retained, or the locations of which have been ascertained from the Owner utility drawings, as well as utility lines encountered during excavation, shall be protected from damage during excavation and backfilling. However, reliance on the information obtained from the Owner drawings does not absolve the Contractor of responsibility for damages, so careful hand methods shall be used to verify the location of underground utilities. Damage shall be reported immediately and satisfactorily repaired by the Contractor at no additional cost. The Contractor shall provide sketches of existing conditions if there are variances, as well as any modifications, on "as-built" drawings. When utility lines that are to be removed are encountered within the area of operations, the Contractor shall give notice in ample time for the necessary measures to be taken to prevent interruption of service.
- D. **Classification Of Excavation:** Excavations specified shall be done on either a classified or unclassified basis as provided for under the item designations of the Contract.
- E. **Utilization Of Excavation Materials:** Unsatisfactory materials removed from excavations shall be disposed in designated areas. Satisfactory material removed from excavations shall be used, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding; as backfill; and for similar purposes. No satisfactory excavated material shall be wasted without specific written authorization. Satisfactory material authorized to be wasted shall be disposed in designated areas approved for surplus material storage or designated waste areas as directed. Coarse rock from excavations shall be stockpiled and used for constructing slopes of embankments adjacent to streams, for constructing slopes or sides and bottoms of channels, and for protecting against erosion. Hand placing of coarse rock from excavations will not be required. Excavated material shall not be disposed in a manner as to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.
- F. **Selection Of Borrow Material:** Borrow material shall be selected to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Borrow material shall be obtained from the borrow areas indicated on the plans or from other approved sources, either private or within the limits of the project site, selected by the Contractor. Unless otherwise provided in the





contract, the Contractor shall obtain from the Owner the right to procure material, pay all royalties and other charges involved, and bear all expense of developing the sources, including rights-of-way for hauling. Borrow material from approved sources on the Owner-controlled land may be obtained without payment of royalties. Unless specifically provided, no borrow shall be obtained within the limits of the project site without prior written approval. Necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris shall be considered related operations to the borrow excavation and shall be performed by the Contractor at no additional cost to the Owner.

- G. Opening And Drainage Of Excavation And Borrow Pits: The Contractor shall give notice sufficiently in advance of the opening of any excavation or borrow pit to permit elevations and measurements of the undisturbed ground surface to be taken. Unless otherwise permitted, borrow pits and other excavation areas shall be excavated in such manner as will afford adequate drainage. Overburden and other spoil material shall be transported to designated spoil areas or otherwise disposed as directed. Borrow pits shall be neatly trimmed and left in such shape as will facilitate accurate measurements after the excavation is completed.
- H. Grading Areas: When so provided and indicated, work under contract will be divided into grading areas, within which satisfactory excavated material shall be placed in embankments, fills, and required backfills. Contractor shall not haul satisfactory material excavated in one grading area to another grading area, except when so directed in writing.
- I. Preparation Of Ground Surface For Embankments
  - 1. Ground surface on which fill is to be placed shall be stripped of live, dead, or decayed vegetation, rubbish, debris, and other unsatisfactory material; shall be plowed, disked, or otherwise broken up; pulverized; moistened or aerated as necessary; mixed; and compacted to at least 90 percent maximum density for cohesive materials or 100 percent maximum density for cohesionless materials.
  - 2. Compaction shall be accomplished by sheepfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment. The prepared ground surface shall be scarified and moistened or aerated just prior to placement of embankment materials to ensure adequate bond between embankment material and the prepared ground surface.
- J. Embankments
  - 1. Earth Embankments
    - a. Earth embankments shall be constructed from satisfactory materials free of organic or frozen material and rocks with maximum dimensions not greater than 3 in. (75 mm). The material shall be placed in successive horizontal layers of loose material not more than 6 in. (150 mm) in depth. Each layer shall be spread uniformly on a prepared surface, i.e., a soil surface that has been moistened or aerated and scarified plowed, disked, or otherwise broken up in such a manner that the fill will bond with the surface on which it is placed, mixed, and compacted to at least 90 percent maximum density for borrow materials or 100 percent maximum density for excavated materials. Compaction requirements for the upper portion of earth embankments forming subgrade for pavements shall be identical to those requirements specified in paragraph entitled, "Subgrade Preparation."
    - b. Compaction shall be accomplished by sheepfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, or other approved equipment.
  - 2. Rock Embankments
    - a. Rock embankments shall be constructed from material essentially classified as rock excavation, placed in successive horizontal layers of loose material not more than 8 to 10 in. (200 to 250 mm) in depth. Pieces of rock larger than 8 to 10 in. (200 to 250 mm) in greatest dimension shall not be used.
    - b. Each layer of material shall be spread uniformly and shall be completely saturated and compacted to density as directed by the Owner.

- c. Each layer of material shall be spread uniformly and shall be completely saturated and compacted until the interstices are filled with well-compacted materials and the entire layer is a dense, compacted mass.
  - d. Each successive layer of material shall adequately bond to the material on which it is placed.
  - e. Compaction shall be accomplished with vibratory compactors with a minimum static weight of 20,000 lbs. (90 kN), heavy rubber-tired rollers weighing not less than 25,000 lbs. (110 kN) or steel-wheeled rollers with a loaded weight of not less than 4,000 lb/ft (58,400 N/m) of drum length.
  - f. Rock shall not be used above a point 6 in. (150 mm) below the surface of an embankment that is to be paved.
- K. Subgrade Preparation
  - 1. Construction
    - a. Subgrade shall be shaped to line, grade, and cross section and compacted as specified. This operation shall include plowing, disking, and any moistening or aerating required to obtain proper compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory excavated material or other approved material as directed. Rock encountered in the cut sections shall be excavated to a depth of 6 in. (150 mm) below finished grade for the subgrade. Low areas resulting from removal of unsatisfactory material or excavation of rock shall be brought up to required grade with satisfactory materials, and the entire subgrade shall be shaped to line, grade, and cross section and compacted as specified.
    - b. After rolling, the surface of the subgrade for roadways and/or airfields shall indicate a deviation not greater than 3/8 in. (10 mm) when tested with a 10-ft (3.0 m) straightedge applied both parallel with, and at right angles to, the centerline of the area.
    - c. Elevation of the finished subgrade shall vary not more than 1/4-in. (6 mm) from the established grade and approved cross section.
  - 2. Compaction: Compaction for pavements and shoulders shall be accomplished with approved equipment until the layer is compacted to the full depth to at least 95 percent maximum density.
- L. Shoulder Construction: Shoulders shall be constructed of satisfactory excavated or borrow materials or as otherwise indicated on the plans. Shoulders shall be constructed as soon as possible after adjacent paving is complete, but in the case of rigid pavements, shoulders shall not be constructed until permission has been obtained. The entire shoulder area shall be compacted to at least the percentage of maximum density as specified for specific ranges of depth below the surface of the shoulder. Compaction shall be accomplished with approved equipment. Shoulder construction shall be done in proper sequence in such a manner that adjacent ditches will be drained effectively and no damage of any kind is done to the adjacent, completed pavement. The completed shoulders shall be true to alignment and grade and shaped to drain in conformity with the cross section indicated.
- M. Finishing: Surface of excavations, embankments, and subgrades shall be finished to a reasonably smooth and compact surface substantially in accordance with the lines, grades, and cross sections or elevations indicated. Degree of finish for graded areas shall be within 1/10 ft (30 mm) of the grades and elevations indicated, except that the degree of finish for subgrades shall be as specified. Gutters and ditches shall be finished as indicated. Surface of areas to be turfed shall be finished to a smoothness suitable for the application of turfing materials.
- N. Subgrade And Embankment Protection: During construction, embankments and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained in such a manner as to drain effectively at all times. Finished subgrade shall not be disturbed by traffic or other operations and shall be protected and maintained by the Contractor in a satisfactory condition until ballast, subbase, base, or pavement is placed. Storage or stockpiling materials on finished subgrade will not be permitted. Subbase, base course, ballast, or pavement shall not be laid until the subgrade has been checked and approved, and in no case shall subbase, base, surfacing, pavement, or ballast be placed on a muddy, spongy, or frozen subgrade.

END OF SECTION 31 23 16 26

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Task	Specification	Specification Description
31 23 16 26	31 01 20 00	Earthwork
31 23 16 33	31 01 20 00	Earthwork
31 23 16 36	31 23 16 13	Excavation Support And Protection
31 23 16 36	31 01 20 00	Earthwork

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## SECTION 31 23 19 00 - DEWATERING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for dewatering. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Performance Requirements

1. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.
  - a. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
  - b. Continuously monitor and maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
  - c. Prevent surface water from entering excavations by grading, dikes, or other means.
  - d. Accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
  - e. Remove dewatering system when no longer required for construction.

#### C. Submittals

1. Shop Drawings: For dewatering system. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.
  - a. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
  - b. Include a written plan for dewatering operations including control procedures to be adopted if dewatering problems arise.
2. Delegated-Design Submittal: For dewatering system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

#### D. Quality Assurance

1. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.
2. Preinstallation Conference: Conduct conference at Project site.

#### E. Project Conditions

1. Interruption of Existing Utilities: Do not interrupt any utility serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed interruption of utility.
  - b. Do not proceed with interruption of utility without the Owner's written permission.
2. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.
  - a. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify the Owner if

changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

## 1.2 PRODUCTS (Not Used)

## 1.3 EXECUTION

### A. Preparation

1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.
  - a. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
  - b. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.
2. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.
  - a. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.
3. Provide temporary grading to facilitate dewatering and control of surface water.
4. Monitor dewatering systems continuously.
5. Promptly repair damages to adjacent facilities caused by dewatering.
6. Protect and maintain temporary erosion and sedimentation controls, which are specified in Division 31 Section "Site Clearing" during dewatering operations.

### B. Installation

1. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.
  - a. Space well points or wells at intervals required to provide sufficient dewatering.
  - b. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.
2. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.
3. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.
  - a. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.
4. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.
  - a. Maintain piezometric water level a minimum of **24 inches (600 mm) OR 60 inches (1500 mm), as directed**, below surface of excavation.
5. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.
6. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to the Owner.

- a. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of **36 inches (900 mm)** below overlying construction.
7. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

END OF SECTION 31 23 19 00

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Task	Specification	Specification Description
31 23 19 00	21 05 23 00	Piped Utilities Basic Materials And Methods
31 23 23 23	31 01 20 00	Earthwork

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## SECTION 31 24 13 00 - LEVEE CLOSURE

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing of labor and materials for providing levee closures.

### 1.2 PRODUCTS - (Not Used)

### 1.3 EXECUTION

#### A. If there is deemed, by the Owner, to be considerable risk of flooding involved with removing drainage structures and gates in the existing Levee System, the Contractor shall perform the work of this contract as follows:

1. Only one drainage structure/flap gate will be allowed to be disrupted at one time. All proposed work at each drainage structure shall be completed before proceeding to the next structure.
2. The Contractor shall have all materials required for each structure installation secured on site, before beginning construction on that structure.
3. The Contractor shall have all necessary materials on site to temporarily plug existing and/or proposed piping through the levee.
4. Weather and river flow conditions shall be monitored at all times by the Contractor while each drainage structure is open to flow. The Contractor shall construct an adequate closure in a timely fashion to plug the drainage structure preventing flow through the levee.

END OF SECTION 31 24 13 00

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Task	Specification	Specification Description
31 24 13 00	31 01 20 00	Earthwork
31 24 13 00	31 23 16 26	Embankment

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## SECTION 31 25 14 13 - GEOSYNTHETIC FABRIC

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing of labor, material and equipment for the installation of geosynthetic fabric.

### 1.2 PRODUCTS

#### A. Materials

1. Erosion Control Fabric - Photo and biodegradable plastic Curlex Blanket as manufactured by American Excelsior Co. or approved equal.
2. Drainage/Leach Bed - Non-woven polypropylene/polyethylene fabric, Mirafi 140N or approved equal.
3. Road Base and Structure Reinforcement - Woven polypropylene fabric, Mirafi 600X or approved equal.
4. Sediment and Job Site erosion control - woven polypropylene fabric - Envirofence by Mirafi or approved equal.

### 1.3 EXECUTION

- #### A.
- For sediment and job site erosion control fabric, the Contractor shall provide and install silt fence as detailed on the Storm Water Management and Erosion Control Plan. It shall be the Contractor's option to provide fabricated reinforced silt fence or prefabricated units, unless otherwise noted. In all installations, the bottom flap of filter cloth shall be firmly embedded into undisturbed or stabilized grade. Embedment shall resist pullout and prevent flow under the installation.

END OF SECTION 31 25 14 13



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Task	Specification	Specification Description
31 25 14 13	01 56 26 00	Sediment Removal
31 25 14 13	01 56 26 00a	Erosion Control
31 25 14 16	01 56 26 00	Sediment Removal
31 25 14 16	31 25 14 13	Geosynthetic Fabric
31 25 14 16	01 56 26 00a	Erosion Control

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## SECTION 31 25 14 23 - UNIT PAVERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for unit pavers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Brick pavers set in aggregate, bituminous or mortar setting beds.
  - b. Concrete pavers set in aggregate, bituminous or mortar setting beds.
  - c. Asphalt-block pavers set in bituminous setting beds.
  - d. Stone pavers set in aggregate or mortar setting beds.
  - e. Plastic or Steel or Aluminum edge restraints.
  - f. Cast-in-place concrete edge restraints.
  - g. Precast concrete curbs.
  - h. Stone curbs.

#### C. Preconstruction Testing

1. Preconstruction Adhesion and Compatibility Testing: Submit to latex-additive manufacturer, for testing as indicated below, samples of paving materials that will contact or affect mortar and grout that contain latex additives.
  - a. Use manufacturer's standard test methods to determine whether mortar and grout materials will obtain optimum adhesion with, and will be nonstaining to, installed pavers and other materials constituting paver installation.

#### D. Action Submittals

1. Product Data: For materials other than water and aggregates.
2. Product Data: For the following:
  - a. Pavers.
  - b. Bituminous setting materials.
  - c. Mortar and grout materials.
  - d. Edge restraints.
  - e. Precast concrete curbs.
  - f. Stone curbs.
3. LEED Submittals:
  - a. Product Certificates for Credit MR 5: For products and materials required to comply with requirements for regional materials, certificates indicating location of material manufacturer and point of extraction, harvest, or recovery for each raw material. Include statement indicating distance to Project, cost for each regional material, and fraction by weight that is considered regional.
4. Adhesion and Compatibility Test Reports: From latex-additive manufacturer for mortar and grout containing latex additives.
5. Sieve Analyses: For aggregate setting-bed materials, according to ASTM C 136.
6. Samples for Initial Selection: For the following:
  - a. Each type of unit paver indicated.
  - b. Joint materials involving color selection.
  - c. Exposed edge restraints involving color selection.
  - d. Precast concrete curbs.
  - e. Granite for stone curbs.
7. Samples for Verification:

- a. Full-size units of each type of unit paver indicated. Assemble no fewer than five Samples of each type of unit on suitable backing and grout joints.]
- b. Joint materials.
- c. Exposed edge restraints.
- d. Precast concrete curbs.
- e. Stone curbs.

**E. Quality Assurance**

1. Source Limitations: Obtain each type of unit paver, joint material, and setting material from single source with resources to provide materials and products of consistent quality in appearance and physical properties.
2. Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and set quality standards for materials and execution.
  - a. Approved mockups may become part of the completed Work if undisturbed at time of Final Completion.
3. Preinstallation Conference: Conduct conference at Project site.

**F. Delivery, Storage, And Handling**

1. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
2. Store cementitious materials on elevated platforms, under cover, and in a dry location. Do not use cementitious materials that have become damp.
3. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.
4. Store liquids in tightly closed containers protected from freezing.
5. Store asphalt cement and other bituminous materials in tightly closed containers.

**G. Project Conditions**

1. Cold-Weather Protection: Do not use frozen materials or build on frozen subgrade or setting beds.
2. Weather Limitations for Bituminous Setting Bed:
  - a. Install bituminous setting bed only when ambient temperature is above 40 deg F (4 deg C) and when base is dry.
  - b. Apply asphalt adhesive only when ambient temperature is above 50 deg F (10 deg C) and when temperature has not been below 35 deg F (2 deg C) for 12 hours immediately before application. Do not apply when setting bed is wet or contains excess moisture.
3. Weather Limitations for Mortar and rout:
  - a. Cold-Weather Requirements: Comply with cold-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602.
  - b. Hot-Weather Requirements: Comply with hot-weather construction requirements contained in ACI 530.1/ASCE 6/TMS 602. Provide artificial shade and windbreaks and use cooled materials as required. Do not apply mortar to substrates with temperatures of 100 deg F (38 deg C) and higher.
    - 1) When ambient temperature exceeds 100 deg F (38 deg C), or when wind velocity exceeds 8 mph (13 km/h) and ambient temperature exceeds 90 deg F (32 deg C), set pavers within 1 minute of spreading setting-bed mortar.

**1.2 PRODUCTS**

**A. Brick Pavers**

1. Regional Materials: Provide brick pavers that have been manufactured within 500 miles (800 km) of Project site from materials that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800 km) of Project site.

2. Brick Pavers: Light-traffic paving brick; ASTM C 902; Class SX for exposure to freezing weather **OR** Class MX for exterior uses that do not expose brick to freezing, **as directed**, Type I for locations exposed to extensive abrasion, such as sidewalks and driveways in public spaces **OR** Type II for locations exposed to intermediate abrasion, such as heavily traveled residential walkways and driveways **OR** Type III for locations exposed to low abrasion, such as floors and patios exposed in single-family homes, **as directed**. Application PS normal tolerance for installation with grouted joints **OR** Application PX close tolerance for ungrouted joints **OR** Application PA non-uniform sized for decorative effect, **as directed**. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
    - a. Thickness: 1-1/4 inches (32 mm) **OR** 1-1/2 inches (38 mm) **OR** 1-5/8 inches (41 mm) **OR** 2-1/4 inches (57 mm) **OR** 2-5/8 inches (67 mm), **as directed**.
    - b. Face Size: 3-3/4 by 7-1/2 inches (95 by 190 mm) **OR** 3-5/8 by 7-5/8 inches (92 by 194 mm) **OR** 3-5/8 by 11-5/8 inches (92 by 295 mm) **OR** 7-5/8 by 7-5/8 inches (194 by 194 mm) **OR** 4 by 8 inches (102 by 203 mm) **OR** 4 by 12 inches (102 by 305 mm) **OR** 8 by 8 inches (203 by 203 mm), **as directed**.
    - c. Color: As selected from manufacturer's full range.
  3. Brick Pavers: Heavy vehicular paving brick; ASTM C 1272, Type F, Application PX **OR** Type R, Application PS **OR** Type R, Application PX **OR** Type R, Application PA, **as directed**. Provide brick without frogs or cores in surfaces exposed to view in the completed Work.
    - a. Type R is for units set in a mortar setting bed or a bituminous setting bed supported by an adequate base. Type F is for units set in a sand setting bed with sand between the pavers. Application PS is for general use; Application PX is for pavers with close dimensional tolerances. Application PX must be selected if specifying Type F.
    - b. Thickness: 2-1/4 inches (57 mm) **OR** 2-5/8 inches (67 mm), **as directed**.
    - c. Face Size: 3-3/4 by 7-1/2 inches (95 by 190 mm) **OR** 3-5/8 by 7-5/8 inches (92 by 194 mm) **OR** 3-5/8 by 11-5/8 inches (92 by 295 mm) **OR** 7-5/8 by 7-5/8 inches (194 by 194 mm) **OR** 4 by 8 inches (102 by 203 mm) **OR** 4 by 12 inches (102 by 305 mm) **OR** 8 by 8 inches (203 by 203 mm), **as directed**.
    - d. Color: As selected from manufacturer's full range.
  4. Efflorescence: Brick shall be rated "not effloresced" when tested according to ASTM C 67.
  5. Temporary Protective Coating: Precoat exposed surfaces of brick pavers with a continuous film of a temporary protective coating that is compatible with brick, mortar, and grout products and can be removed without damaging grout or brick. Do not coat unexposed brick surfaces; handle brick to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.
- B. Concrete Pavers
1. Concrete Pavers: Solid interlocking paving units complying with ASTM C 936 and resistant to freezing and thawing when tested according to ASTM C 67, made from normal-weight aggregates.
    - a. Thickness: 2-3/8 inches (60 mm) **OR** 3-1/8 inches (80 mm), **as directed**.
    - b. Face Size and Shape: 3-7/8 inches (98 mm) square **OR** 4-7/16 inches (113 mm) **OR** 8-7/8 inches (225 mm) **OR** 9 inches (229 mm) square, **as directed**.
    - c. Face Size and Shape: 3-7/8-by-7-7/8 inch (98-by-200 mm) **OR** 4-by-8-inch (102-by-203-mm) **OR** 4-7/16-by-8-7/8 inch (113-by-225-mm), **as directed**, rectangle.
    - d. Face Size and Shape: 5-1/2-inch (140-mm) octagon with attached 3-1/2-inch (89-mm) square **OR** 4-1/2-by-9 inch (114-by-229 mm) rectangle with saw-tooth edges **OR** 4-3/4-inch (121-mm) rectangular and trapezoidal units arranged in semicircular courses to produce fan-shaped pattern, **as directed**.
    - e. Color: As selected from manufacturer's full range.
  2. Concrete Pavers: Solid paving units, made from normal-weight concrete with a compressive strength not less than 5000 psi (34 MPa) **OR** 6000 psi (41 MPa), **as directed**, water absorption not more than 5 percent according to ASTM C 140, and no breakage and not more than 1 percent mass loss when tested for freeze-thaw resistance according to ASTM C 67.

- a. Thickness: **1-5/8 inches (41 mm) OR 1-3/4 inches (45 mm) OR 2 inches (51 mm) OR 2-3/8 inches (60 mm), as directed.**
  - b. Face Size and Shape: **8-7/8 inches (225 mm) square OR 9 inches (229 mm) square OR 12 inches (305 mm) square OR 18 inches (457 mm) square OR 24 inches (610 mm) square, as directed.**
  - c. Face Size and Shape: **9-by-18 inch (229-by-457 mm) OR 12-by-24 inch (305-by-610 mm), as directed, rectangle.**
  - d. Face Size and Shape: As indicated.
  - e. Color: As selected from manufacturer's full range.
3. Concrete Pavers: Solid paving units complying with ASTM C 1491, made from lightweight concrete.
  - a. Thickness: **1-5/8 inches (41 mm) OR 1-3/4 inches (45 mm) OR 2 inches (51 mm), as directed.**
  - b. Face Size and Shape: **9 inches (229 mm) square OR 12 inches (305 mm) square OR 18 inches (457 mm) square, as directed.**
  - c. Color: As selected from manufacturer's full range.
- C. Asphalt-Block Pavers
  1. Asphalt-Block Pavers: Solid units made from asphalt cement complying with ASTM D 312, Type III; inorganic stone dust or cement filler; and coarse aggregate, consisting of clean, hard, unweathered stone crushed into angular particles varying in size up to **3/8 inch (9.5 mm).**
    - a. Thickness: **1-1/4 inches (32 mm) OR 2 inches (51 mm) OR 3 inches (76 mm), as directed.**
    - b. Face Size: **4 by 6 inches (102 by 152 mm) OR 6 by 6 inches (152 by 152 mm) OR 8 by 8 inches (203 by 203 mm) OR 5 by 12 inches (127 by 305 mm) OR 6 by 12 inches (152 by 305 mm) OR 8-inch- (203-mm-) wide hexagon, as directed.**
    - c. Finish: Natural, smooth **OR** Ground **OR** Ground and sandblasted, **as directed.**
    - d. Color: As selected from manufacturer's full range.
- D. Stone Pavers
  1. Granite Pavers: Rectangular paving slabs made from granite complying with ASTM C 615
    - a. Color and Grain: Light gray **OR** Dark gray **OR** Buff **OR** White **OR** Black **OR** Pink, **as directed, with medium OR fine, as directed, grain.**
    - b. Finish: Honed **OR** Thermal, **as directed.**
    - c. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
    - d. Thickness: Not less than **3/4 inch (20 mm) OR 30 mm OR 1-1/4 inches (32 mm) OR 1-5/8 inches (40 mm), as directed, unless otherwise indicated.**
    - e. Face Size: **9 inches (229 mm) square OR 12 inches (305 mm) square OR 18 inches (457 mm) square OR 9 by 18 inches (229 by 457 mm), as directed.**
  2. Limestone Pavers: Rectangular paving slabs made from limestone complying with ASTM C 568.
    - a. Classification: II Medium-Density **OR** III High-Density, **as directed.**
    - b. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C 241 or ASTM C 1353.
    - c. Finish: Smooth **OR** Chat sawed **OR** Shot sawed, **as directed.**
    - d. Match Architect's samples for color, finish, and other stone characteristics relating to aesthetic effects.
    - e. Thickness: Not less than **1 inch (25 mm) OR 1-1/4 inches (32 mm) OR 1-5/8 inches (40 mm) OR 2 inches (50 mm), as directed, unless otherwise indicated.**
    - f. Face Size: **9 inches (229 mm) square OR 12 inches (305 mm) square OR 18 inches (457 mm) square OR 9 by 18 inches (229 by 457 mm), as directed.**
  3. Marble Pavers: Rectangular paving slabs made from marble complying with ASTM C 503.
    - a. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C 241 or ASTM C 1353.
    - b. Description: Uniform, fine- to medium-grained, white stone with only slight veining.

- c. Finish: Honed **OR as directed.**
- d. Match samples for color, finish, and other stone characteristics relating to aesthetic effects.
- e. Thickness: Not less than **3/4 inch (20 mm) OR 30 mm OR 1-1/4 inches (32 mm), as directed.**
- f. Face Size: **9 inches (229 mm) square OR 12 inches (305 mm) square OR 18 inches (457 mm) square OR 9 by 18 inches (229 by 457 mm) as directed.**
4. Quartz-Based Stone Pavers: Rectangular paving slabs **OR** Random polygonal flagstones made from quartz-based stone complying with ASTM C 616, Classification I Sandstone **OR** II Quartzitic Sandstone **OR** III Quartzite, **as directed.**
  - a. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C 241 or ASTM C 1353.
  - b. Finish: Sand rubbed **OR** Natural cleft **OR** Thermal, **as directed.**
  - c. Match samples for color, finish, and other stone characteristics relating to aesthetic effects.
  - d. Thickness: Not less than **1 inch (25 mm) OR 1-1/4 inches (32 mm) OR 1-1/2 inches (38 mm) OR 1-5/8 inches (40 mm) OR 2 inches (50 mm), as directed.**
  - e. Face Size: **9 inches (229 mm) square OR 12 inches (305 mm) square OR 18 inches (457 mm) square OR 9 by 18 inches (229 by 457 mm), as directed.**
5. Slate Pavers: Rectangular paving slabs **OR** Random polygonal flagstones made from slate complying with ASTM C 629, Classification I Exterior, with a fine, even grain and unfading color, from clear, sound stock.
  - a. Color: Black **OR** Blue-black **OR** Gray **OR** Blue-gray **OR** Green **OR** Purple **OR** Mottled purple and green **OR** Red, **as directed.**
  - b. Stone Abrasion Resistance: Minimum value of 8, based on testing according to ASTM C 241 or ASTM C 1353.
  - c. Finish: Honed **OR** Sand rubbed **OR** Natural cleft, **as directed.**
  - d. Match samples for color, finish, and other stone characteristics relating to aesthetic effects.
  - e. Thickness: Not less than **1/2 inch (13 mm) OR 3/4 inch (20 mm) OR 1 inch (25 mm), as directed.**
  - f. Face Size: **9 inches (229 mm) square OR 12 inches (305 mm) square OR 18 inches (457 mm) square OR 9 by 18 inches (229 by 457 mm), as directed.**
6. Travertine Pavers: Rectangular paving slabs made from travertine complying with ASTM C 1527, Classification I Exterior.
  - a. Stone Abrasion Resistance: Minimum value of 10, based on testing according to ASTM C 241 or ASTM C 1353.
  - b. Cut: Vein cut.
  - c. Filling: Fill pores on faces of stone with cementitious filler of color as selected by the Owner.
  - d. Finish: Honed **OR as directed.**
  - e. Match samples for color, finish, and other stone characteristics relating to aesthetic effects.
  - f. Thickness: Not less than **3/4 inch (20 mm) OR 30 mm OR 1-1/4 inches (32 mm), as directed.**
  - g. Face Size: **9 inches (229 mm) square OR 12 inches (305 mm) square OR 18 inches (457 mm) square OR 9 by 18 inches (229 by 457 mm), as directed.**
7. Rough-Stone Pavers: Rectangular tumbled paving stones, with split or thermal-finished faces and edges, made from granite complying with ASTM C 615.
  - a. Granite Color and Grain: Light gray **OR** Dark gray **OR** Buff **OR** White **OR** Black **OR** Pink, **as directed**, with medium **OR** fine, **as directed**, grain.
  - b. Thickness: **1-1/4 inches (32 mm) OR 2 inches (51 mm) OR 3 inches (76 mm) OR 4 inches (102 mm) OR 4 inches (102 mm), plus or minus 1/2 inch (13 mm), as directed.**
  - c. Face Size: **4 by 4 inches (100 by 100 mm), plus or minus 1/2 inch (13 mm) OR 3 to 5 inches (75 to 125 mm) by 8 to 12 inches (200 to 300 mm), as directed.**
- E. Curbs And Edge Restraints
  1. Plastic Edge Restraints: Manufacturer's standard triangular PVC extrusions **1-3/4 inches (45 mm) high by 3-1/2 inches (89 mm) wide OR 3-1/8 inches (79 mm) high by 9-1/2 inches (241 mm) wide, as directed**, designed to serve as edge restraints for unit pavers; rigid type for straight



edges and flexible type for curved edges, with pipe connectors and **3/8-inch (9.5-mm)** diameter by **12-inch- (300-mm-)** long steel spikes.

2. Steel Edge Restraints: Manufacturer's standard painted steel edging **3/16 inch (4.8 mm)** thick by **4 inches (100 mm)** high **OR** **1/4 inch (6.4 mm)** thick by **5 inches (125 mm)** high, **as directed** with loops pressed from or welded to face to receive stakes at **36 inches (900 mm)** o.c., and steel stakes **15 inches (380 mm)** long for each loop.
  - a. Color: As selected from manufacturer's full range.
3. Aluminum Edge Restraints: Manufacturer's standard straight, **1/8-inch- (3.2-mm-)** thick by **4-inch- (100-mm-)** high **OR** straight, **3/16-inch- (4.8-mm-)** thick by **4-inch- (100-mm-)** high **OR** L-shaped, **1/8-inch- (3.2-mm-)** thick by **1-3/8-inch- (35-mm-)** high **OR** L-shaped, **3/16-inch- (4.8-mm-)** thick by **2-1/4-inch- (57-mm-)** high, **as directed** extruded-aluminum edging with loops pressed from face to receive stakes at **12 inches (300 mm)** o.c., and aluminum stakes **12 inches (300 mm)** long for each loop.
4. Job-Built Concrete Edge Restraints: Comply with requirements in Division 3 Section "Cast-in-Place Concrete" for normal-weight, air-entrained, ready-mixed concrete with minimum 28-day compressive strength of **3000 psi (20 MPa)**.
5. Precast Concrete Curbs: Made from normal-weight concrete with a compressive strength not less than **5000 psi (34 MPa)** **OR** **6000 psi (41 MPa)**, **as directed** and water absorption not more than 5 percent, in shapes and sizes indicated.
6. Stone Curbs: Granite curbing, with face battered **1 inch per foot (1:12)**, produced in random lengths not less than **36 inches (900 mm)** from granite complying with ASTM C 615.
  - a. Granite Color and Grain: Light gray **OR** Dark gray **OR** Buff **OR** White **OR** Black **OR** Pink, **as directed** with fine **OR** medium **OR** coarse grain, **as directed**.
  - b. Top Width: **4 inches (102 mm)** **OR** **5 inches (127 mm)** **OR** **6 inches (152 mm)**, **as directed**.
  - c. Face Height: **4 inches (102 mm)** **OR** **6 inches (152 mm)** **OR** **8 inches (203 mm)**, **as directed**.
  - d. Total Height: **12 inches (305 mm)** **OR** **16 inches (406 mm)** **OR** **18 inches (457 mm)**, **as directed**.
  - e. Top Finish: Sawed **OR** Thermal **OR** Bush hammered, **as directed**.
  - f. Face Finish: Split **OR** Sawed **OR** Thermal **OR** Bush hammered, **as directed**.

F. Accessories

1. Cork Joint Filler: Preformed strips complying with ASTM D 1752, Type II.
2. Compressible Foam Filler: Preformed strips complying with ASTM D 1056, Grade 2A1.

G. Aggregate Setting-Bed Materials

1. Graded Aggregate for Sub-base: Sound, crushed stone or gravel complying with ASTM D 448 for Size No. 57 **OR** ASTM D 2940, sub-base material **OR** requirements in Division 31 Section "Earth Moving" for sub-base material, **as directed**.
2. Graded Aggregate for Base: Sound, crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** ASTM D 2940, base material **OR** requirements in Division 31 Section "Earth Moving" for base course, **as directed**.
3. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.
4. Stone Screenings for Leveling Course: Sound stone screenings complying with ASTM D 448 for Size No. 10.
5. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing **No. 16 (1.18-mm)** sieve and no more than 10 percent passing **No. 200 (0.075-mm)** sieve.
  - a. Provide sand of color needed to produce required joint color.
6. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications; made from polyolefins or polyesters, with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
  - a. Survivability: Class 2, AASHTO M 288.
  - b. Apparent Opening Size: **No. 60 (0.250-mm)** sieve, maximum; ASTM D 4751.

- c. Permittivity: 0.02 per second, minimum; ASTM D 4491.
    - d. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.
  7. Drainage Geotextile: Nonwoven needle-punched geotextile made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
    - a. Survivability: Class 2, AASHTO M 288.
    - b. Apparent Opening Size: **No. 40 (0.425-mm)** sieve, maximum; ASTM D 4751.
    - c. Permittivity: 0.5 per second, minimum; ASTM D 4491.
    - d. UV Stability: 50 percent after 500 hours' exposure, ASTM D 4355.
  8. Herbicide: Commercial chemical for weed control, registered with the EPA. Provide in granular, liquid, or wettable powder form.
- H. Bituminous Setting-Bed Materials
1. Primer for Base: ASTM D 2028, cutback asphalt, grade as recommended by unit paver manufacturer.
  2. Fine Aggregate for Setting Bed: ASTM D 1073, No. 2 or No. 3.
  3. Asphalt Cement: ASTM D 3381, Viscosity Grade AC-10 or Grade AC-20.
  4. Neoprene-Modified Asphalt Adhesive: Paving manufacturer's standard adhesive consisting of oxidized asphalt combined with 2 percent neoprene and 10 percent long-fibered mineral fibers containing no asbestos.
  5. Sand for Joints: Fine, sharp, washed, natural sand or crushed stone with 100 percent passing **No. 16 (1.18-mm)** sieve and no more than 10 percent passing **No. 200 (0.075-mm)** sieve.
    - a. Provide sand of color needed to produce required joint color.
- I. Mortar Setting-Bed Materials
1. Portland Cement: ASTM C 150, Type I or II.
  2. Hydrated Lime: ASTM C 207, Type S.
  3. Sand: ASTM C 144.
  4. Latex Additive: Manufacturer's standard, acrylic resin or styrene-butadiene-rubber water emulsion, **as directed** serving as replacement for part or all of gaging water, of type specifically recommended by latex-additive manufacturer for use with field-mixed portland cement and aggregate mortar bed, and not containing a retarder.
  5. Thinset Mortar: Latex-modified portland cement mortar complying with ANSI A118.4.
    - a. Provide prepackaged, dry-mortar mix containing dry, redispersible, vinyl acetate or acrylic additive to which only water must be added at Project site.
    - b. Provide prepackaged, dry-mortar mix combined with acrylic resin or styrene-butadiene-rubber liquid-latex additive at Project site, as directed.
  6. Water: Potable.
  7. Reinforcing Wire Fabric: Galvanized, welded wire fabric, **2-by-2-inch (51-by-51-mm)** by **0.062-inch- (1.57-mm-)** diameter wire; comply with ASTM A 1064/A 1064M and ASTM A 82/A 82M except for minimum wire size.
- J. Grout Materials
1. Sand-Portland Cement Grout: ANSI A108.10, composed of white or gray cement, unfading mineral pigments and white or colored sand as required to produce required color.
    - a. Colored Mortar Pigments for Grout: Natural and synthetic iron and chromium oxides, compounded for use in mortar and grout mixes. Use only pigments that have proved, through testing and experience, to be satisfactory for use in portland cement grout.
  2. Standard Cement Grout: ANSI A118.6, sanded.
  3. Polymer-Modified Grout: ANSI A118.7, sanded grout; in color indicated.
    - a. Polymer Type: Ethylene-vinyl acetate or acrylic additive in dry, redispersible form; prepackaged with other dry ingredients.
    - b. Polymer Type: Acrylic resin or styrene-butadiene rubber in liquid-latex form for addition to prepackaged dry-grout mix.
  4. Grout Colors: As selected from manufacturer's full range.
  5. Water: Potable.

**K. Bituminous Setting-Bed Mix**

1. Mix bituminous setting-bed materials at an asphalt plant in approximate proportion, by weight, of 7 percent asphalt cement to 93 percent fine aggregate, unless otherwise indicated. Heat mixture to **300 deg F (149 deg C)**.

**L. Mortar And Grout Mixes**

1. General: Comply with referenced standards and with manufacturers' written instructions. Discard mortars and grout if they have reached their initial set before being used.
2. Mortar-Bed Bond Coat: Mix neat cement or cement and sand with latex additive **OR** water, **as directed**, to a creamy consistency.
3. Portland Cement-Lime Setting-Bed Mortar: Type M complying with ASTM C 270, Proportion Specification.
4. Latex-Modified, Portland Cement Setting-Bed Mortar: Proportion and mix portland cement, sand, and latex additive for setting bed to comply with written instructions of latex-additive manufacturer and as necessary to produce stiff mixture with a moist surface when bed is ready to receive pavers.
5. Latex-Modified, Portland Cement Slurry Bond Coat: Proportion and mix portland cement, aggregate, and liquid latex for bond coat to comply with written instructions of liquid-latex manufacturer.
6. Thinset Mortar Bond Coat: Proportion and mix thinset mortar ingredients according to manufacturer's written instructions.
7. Job-Mixed Portland Cement Grout: Proportion and mix job-mixed portland cement and aggregate grout to match setting-bed mortar except omit hydrated lime and use enough water to produce a pourable mixture.
  - a. Pigmented Grout: Select and proportion pigments with other ingredients to produce color required. Do not exceed pigment-to-cement ratio of 1:10, by weight.
  - b. Colored-Aggregate Grout: Produce color required by combining colored sand with portland cement of selected color.
8. Package Grout Mix: Proportion and mix grout ingredients according to grout manufacturer's written instructions.

**1.3 EXECUTION****A. Examination**

1. Examine areas indicated to receive paving, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
2. Where pavers are to be installed over waterproofing, examine waterproofing installation, with waterproofing Installer present, for protection from paving operations, including areas where waterproofing system is turned up or flashed against vertical surfaces.
3. Proceed with installation only after unsatisfactory conditions have been corrected and waterproofing protection is in place.

**B. Preparation**

1. Remove substances from concrete substrates that could impair mortar bond, including curing and sealing compounds, form oil, and laitance.
2. Sweep concrete substrates to remove dirt, dust, debris, and loose particles.
3. Proof-roll prepared subgrade according to requirements in Division 31 Section "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with unit paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base course for unit pavers.

**C. Installation, General**

1. Do not use unit pavers with chips, cracks, voids, discolorations, or other defects that might be visible or cause staining in finished work.

2. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.
3. Cut unit pavers with motor-driven masonry saw equipment to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible.
  - a. For concrete pavers, a block splitter may be used.
4. Handle protective-coated brick pavers to prevent coated surfaces from contacting backs or edges of other units. If, despite these precautions, coating does contact bonding surfaces of brick, remove coating from bonding surfaces before setting brick.
5. Joint Pattern: Running bond **OR** Herringbone **OR** Basket weave **OR** Match and continue existing unit paver joint pattern, **as directed**.
6. Pavers over Waterproofing: Exercise care in placing pavers and setting materials over waterproofing so protection materials are not displaced and waterproofing is not punctured or otherwise damaged. Carefully replace protection materials that become displaced and arrange for repair of damaged waterproofing before covering with paving.
  - a. Provide joint filler at waterproofing that is turned up on vertical surfaces, unless otherwise indicated; where unfilled joints are indicated, provide temporary filler or protection until paver installation is complete.
7. Tolerances: For smooth pavers where slopes to drains are critical. Do not exceed **1/32-inch (0.8-mm)** unit-to-unit offset from flush (lippage) nor **1/8 inch in 10 feet (3 mm in 3 m)** from level, or indicated slope, for finished surface of paving.  
**OR**  
Tolerances: For smooth, flat pavers. Do not exceed **1/16-inch (1.6-mm)** unit-to-unit offset from flush (lippage) nor **1/8 inch in 24 inches (3 mm in 600 mm)** and **1/4 inch in 10 feet (6 mm in 3 m)** from level, or indicated slope, for finished surface of paving.
8. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide compressible foam filler as backing for sealant-filled joints unless otherwise indicated; where unfilled joints are indicated, provide temporary filler until paver installation is complete. Install joint filler before setting pavers. Sealant materials and installation are specified in Division 07 Section "Joint Sealants".  
**OR**  
Expansion and Control Joints: Provide cork joint filler at locations and of widths indicated. Install joint filler before setting pavers. Make top of joint filler flush with top of pavers.
9. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
  - a. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after unit paver installation.
  - b. For metal edge restraints with top edge exposed, drive stakes at least **1 inch (25 mm)** below top edge.
  - c. Install job-built concrete edge restraints to comply with requirements in Division 03 Section "Cast-in-place Concrete".
  - d. Where pavers set in mortar bed are indicated as edge restraints for pavers set in aggregate setting bed, install pavers set in mortar and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.
  - e. Where pavers embedded in concrete are indicated as edge restraints for pavers set in aggregate setting bed, install pavers embedded in concrete and allow concrete to cure before placing aggregate setting bed and remainder of pavers. Hold top of concrete below aggregate setting bed.
10. Provide steps made of pavers as indicated. Install paver steps before installing adjacent pavers.
  - a. Where pavers set in mortar bed are indicated for steps constructed adjacent to pavers set in aggregate setting bed, install steps and allow mortar to cure before placing aggregate setting bed and remainder of pavers. Cut off mortar bed at a steep angle so it will not interfere with aggregate setting bed.

D. Aggregate Setting-Bed Applications

1. Compact soil subgrade uniformly to at least 95 percent of ASTM D 698 **OR** ASTM D 1557, **as directed**, laboratory density.

2. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined, and replace with compacted backfill or fill as directed.
3. Place separation geotextile over prepared subgrade, overlapping ends and edges at least **12 inches (300 mm)**.
4. Place aggregate subbase and base **OR** base, **as directed**.
  - a. For light-traffic compact by tamping with plate vibrator, and screed to depth indicated.
  - b. For heavy duty compact to 100 percent of ASTM D 1557 maximum laboratory density, and screed to depth indicated.
5. Place drainage geotextile over compacted base course, overlapping ends and edges at least **12 inches (300 mm)**.
6. Place leveling course and screed to a thickness of **1 to 1-1/2 inches (25 to 38 mm)**, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.
7. Treat leveling course with herbicide to inhibit growth of grass and weeds.
8. Set pavers with a minimum joint width of **1/16 inch (1.5 mm)** and a maximum of **1/8 inch (3 mm)**, being careful not to disturb leveling base. If pavers have spacer bars, place pavers hand tight against spacer bars. Use string lines to keep straight lines. Fill gaps between units that exceed **3/8 inch (10 mm)** with pieces cut to fit from full-size unit pavers.
  - a. When installation is performed with mechanical equipment, use only unit pavers with spacer bars on sides of each unit.
9. Vibrate pavers into leveling course with a low-amplitude plate vibrator capable of a **3500- to 5000-lbf (16- to 22-kN)** compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
  - a. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least **36 inches (900 mm)** of uncompacted pavers adjacent to temporary edges.
  - b. Before ending each day's work, compact installed concrete pavers except for **36-inch (900 mm)** width of uncompacted pavers adjacent to temporary edges (laying faces).
  - c. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within **36 inches (90 mm)** of laying face.
  - d. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and cover leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.
10. Spread dry sand and fill joints immediately after vibrating pavers into leveling course. Vibrate pavers and add sand until joints are completely filled, then remove excess sand. Leave a slight surplus of sand on the surface for joint filling.
11. Do not allow traffic on installed pavers until sand has been vibrated into joints.
12. Repeat joint-filling process 30 days later.

**E. Bituminous Setting-Bed Applications**

1. Apply primer to concrete slab or binder course immediately before placing setting bed.
2. Prepare for setting-bed placement by locating **3/4-inch- (19-mm-)** deep control bars approximately **11 feet (3.3 m)** apart, to serve as guides for striking board. Adjust bars for accurate setting of paving units to finished grades indicated.
3. Place bituminous setting bed between control bars. Spread mix at a minimum temperature of **250 deg F (121 deg C)**. Strike setting bed smooth, firm, even, and not less than **3/4 inch (19 mm)** thick. Add fresh bituminous material to low, porous spots after each pass of striking board. Carefully fill depressions that remain after removing depth-control bars.
  - a. Roll setting bed with power roller to a nominal depth of **3/4 inch (19 mm)**. Adjust thickness as necessary to allow accurate setting of unit pavers to finished grades indicated. Complete rolling before mix temperature cools to **185 deg F (85 deg C)**.
4. Apply neoprene-modified asphalt adhesive to cold setting bed by squeegeeing or troweling to a uniform thickness of **1/16 inch (1.6 mm)**. Proceed with setting of paving units only after adhesive is tacky and surface is dry to touch.



5. Place pavers carefully by hand in straight courses, maintaining accurate alignment and uniform top surface. Protect newly laid pavers with plywood panels on which workers can stand. Advance protective panels as work progresses, but maintain protection in areas subject to continued movement of materials and equipment to avoid creating depressions or disrupting alignment of pavers. If additional leveling of paving is required, and before treating joints, roll paving with power roller after sufficient heat has built up in the surface from several days of hot weather.
  6. Joint Treatment: Place unit pavers with hand-tight joints. Fill joints by sweeping sand over paved surface until joints are filled. Remove excess sand after joints are filled.
- F. Mortar Setting-Bed Applications
1. Saturate concrete sub-base with clean water several hours before placing setting bed. Remove surface water about one hour before placing setting bed.
  2. Apply mortar-bed bond coat over surface of concrete sub-base about 15 minutes before placing setting bed. Limit area of bond coat to avoid its drying out before placing setting bed. Do not exceed **1/16-inch (1.6-mm)** thickness for bond coat.
  3. Apply mortar bed over bond coat immediately after applying bond coat. Spread and screed to subgrade elevations required for accurate setting of pavers to finished grades indicated.
  4. Place reinforcing wire over concrete sub-base, lapped at joints by at least one full mesh and supported so mesh becomes embedded in the middle of setting bed. Hold edges back from vertical surfaces approximately **1/2 inch (13 mm)**.
  5. Place mortar bed with reinforcing wire fully embedded in middle of setting bed. Spread and screed setting bed to uniform thickness at subgrade elevations required for accurate setting of pavers to finished grades indicated.
  6. Mix and place only that amount of mortar that can be covered with pavers before initial set. Cut back and discard setting-bed material that has reached initial set before placing pavers.
  7. Wet brick pavers before laying if the initial rate of absorption exceeds **30 g/30 sq. in. (30 g/194 sq. cm)** per minute when tested per ASTM C 67. Allow units to absorb water so they are damp but not wet at time of laying.
  8. Place pavers before initial set of cement occurs. Immediately before placing pavers, apply uniform **1/16-inch- (1.5-mm-)** thick, slurry bond coat to bed or to back of each paver.
  9. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set or disturb pavers for purposes of realigning finished surfaces or adjusting joints.
  10. Spaced Joint Widths: Provide **3/8-inch (10-mm) OR 1/2-inch (13-mm) OR 3/4-inch (19-mm)**, as **directed**, nominal joint width with variations not exceeding plus or minus **1/16 inch (1.5 mm) OR 1/8 inch (3 mm) OR 3/16 inch (4.5 mm)**, as **directed**.
  11. Grouted Joints: Grout paver joints complying with ANSI A108.10.
  12. Grout joints as soon as possible after initial set of setting bed.
    - a. Force grout into joints, taking care not to smear grout on adjoining surfaces.
    - b. Clean pavers as grouting progresses by dry brushing or rubbing with dry burlap to remove smears before tooling joints.
    - c. Tool exposed joints slightly concave when thumbprint hard.
    - d. If tooling squeezes grout from joints, remove excess grout and smears by dry brushing or rubbing with dry burlap and tool joints again to produce a uniform appearance.
  13. Cure grout by maintaining in a damp condition for seven days, unless otherwise recommended by grout or liquid-latex manufacturer.
- G. Repairing, Pointing, And Cleaning
1. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.
  2. Pointing: During tooling of joints, enlarge voids or holes and completely fill with grout. Point joints at sealant joints to provide a neat, uniform appearance, properly prepared for sealant application.



3. Cleaning: Remove excess grout from exposed paver surfaces; wash and scrub clean.
  - a. Remove temporary protective coating as recommended by coating manufacturer and as acceptable to paver and grout manufacturers.
  - b. Do not allow protective coating to enter floor drains. Trap, collect, and remove coating material.

END OF SECTION 31 25 14 23

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Task	Specification	Specification Description
31 25 14 23	01 56 26 00	Sediment Removal
31 25 14 23	31 25 14 13	Geosynthetic Fabric
31 25 14 23	01 56 26 00a	Erosion Control

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## SECTION 31 25 14 26 - SILT FENCES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing of labor, material and equipment for the installation of silt fencing.

### 1.2 PRODUCTS

#### A. Materials

1. Fabricated Units
  - a. Posts: 36" long, 2" hardwood or "T" or "U" type steel.
  - b. Fence: Woven wire, 14-1/2 ga. 6-inch max. mesh opening.
  - c. Filter Cloth: MIRAFL 100X or approved equal.
2. Prefabricated Units
  - a. Envirofence by MIRAFL or approved equal.

### 1.3 EXECUTION

- #### A.
- The Contractor shall provide and install silt fences as directed by the Owner. It shall be the Contractor's option to provide fabricated reinforced silt fence or prefabricated units, unless otherwise directed. In all installations, the bottom flap of filter cloth shall be firmly embedded into undisturbed or stabilized grade. Embedment shall resist pullout and prevent flow under the installation.

END OF SECTION 31 25 14 26

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Task	Specification	Specification Description
31 25 14 26	01 56 26 00	Sediment Removal
31 25 14 26	01 56 26 00a	Erosion Control

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## SECTION 31 31 16 13 - TERMITE CONTROL

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for termite control. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Soil and wood treatment with termiticide.
  - b. Bait-station system.
  - c. Metal mesh barrier system.
  - d. Polymer sheet barrier system with termiticide.
  - e. Polymer barrier fittings with termiticide for installation around utility penetrations.

#### C. Submittals

1. Product Data: For each type of termite control product.
  - a. Include the EPA-Registered Label for termiticide products.
2. Qualification Data: For qualified Installer.
3. Product Certificates: For termite control products, from manufacturer.
4. Soil Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:
  - a. Date and time of application.
  - b. Moisture content of soil before application.
  - c. Termiticide brand name and manufacturer.
  - d. Quantity of undiluted termiticide used.
  - e. Dilutions, methods, volumes used, and rates of application.
  - f. Areas of application.
  - g. Water source for application.
5. Wood Treatment Application Report: After application of termiticide is completed, submit report for Owner's records and include the following:
  - a. Date and time of application.
  - b. Termiticide brand name and manufacturer.
  - c. Quantity of undiluted termiticide used.
  - d. Dilutions, methods, volumes used, and rates of application.
  - e. Areas of application.
6. Bait-Station System Application Report: After installation of bait-station system is completed, submit report for Owner's records and include the following:
  - a. Location of areas and sites conducive to termite feeding and activity.
  - b. Plan drawing showing number and locations of bait stations.
  - c. Dated report for each monitoring and inspection occurrence indicating level of termite activity, procedure, and treatment applied before time of Final Completion.
  - d. Termiticide brand name and manufacturer.
  - e. Quantities of termiticide and nontoxic termite bait used.
  - f. Schedule of inspections for one year from date of Final Completion.
7. Polymer Sheet Barrier System with Termiticide Application Report: After installation of polymer sheet barrier system with termiticide is completed, submit report for Owner's records and include the following:
  - a. Plan drawing showing extent of sheet barrier and number and locations of each type of polymer barrier fitting.
  - b. Termiticide brand name and manufacturer.



- c. Schedule of inspections for one year from date of Final Completion.
  8. Polymer Barrier Fittings with Termiticide Application Report: After installation of polymer barrier fittings with termiticide is completed, submit report for Owner's records and include the following:
    - a. Plan drawing showing number and locations of each type of polymer barrier fitting with termiticide.
    - b. Termiticide brand name and manufacturer.
    - c. Schedule of inspections for one year from date of Final Completion.
  9. Warranties: Sample of special warranties.
- D. Quality Assurance
  1. Installer Qualifications: A specialist who is licensed according to regulations of authorities having jurisdiction to apply termite control treatment and products in jurisdiction where Project is located, and who employs workers trained and approved by manufacturer to install manufacturer's products.
  2. Regulatory Requirements: Formulate and apply termiticides and termiticide devices according to the EPA-Registered Label.
  3. Source Limitations: Obtain termite control products from single source.
  4. Preinstallation Conference: Conduct conference at Project site.
- E. Project Conditions
  1. Environmental Limitations: To ensure penetration, do not treat soil that is water saturated or frozen. Do not treat soil while precipitation is occurring. Comply with requirements of the EPA-Registered Label and requirements of authorities having jurisdiction.
  2. Coordinate soil treatment application with excavating, filling, grading, and concreting operations. Treat soil under footings, grade beams, and ground-supported slabs before construction.
  3. Apply wood treatment after framing, sheathing, and exterior weather protection is completed but before electrical and mechanical systems are installed.
  4. Install bait-station system during construction to determine areas of termite activity and after construction, including landscaping, is completed.
  5. Install polymer sheet barrier system with termiticide prior to placing concrete slab reinforcement and pouring concrete and after installation and inspection of footings, foundations, and plumbing and electrical pipes and conduits.
  6. Install polymer barrier fittings with termiticide around utility penetrations prior to pouring concrete and after installation and inspection of plumbing and electrical pipes and conduits, slab vapor barrier, and concrete slab reinforcement.
- F. Warranty
  1. Soil Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of applied soil termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat soil and repair or replace damage caused by termite infestation.
    - a. Warranty Period: Three **OR** Five, **as directed**, years from date of Final Completion.
  2. Wood Treatment Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of applied wood termiticide treatment, will prevent infestation of subterranean termites. If subterranean termite damage is discovered during warranty period, repair or replace damage caused by termite infestation and treat replacement wood.
    - a. Warranty Period: 12 years from date of Final Completion.
  3. Polymer Sheet Barrier System with Termiticide Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of installation of polymer sheet barrier system with termiticide, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat and repair or replace damage caused by termite infestation.
    - a. Warranty Period: 10 years from date of Final Completion.

4. Polymer Barrier Fittings with Termiticide Special Warranty: Manufacturer's standard form, signed by Applicator and Contractor, certifying that termite control work, consisting of installation of polymer barrier fittings with termiticide, will prevent infestation of subterranean termites. If subterranean termite activity or damage is discovered during warranty period, re-treat and repair or replace damage caused by termite infestation.
  - a. Warranty Period: Five years from date of Final Completion.

G. Maintenance Service

1. Continuing Service (as directed): Beginning at Final Completion, provide 12 months' continuing service including monitoring, inspection, and re-treatment for occurrences of termite activity. Provide a standard continuing service agreement. State services, obligations, conditions, terms for agreement period, and terms for future renewal options.

## 1.2 PRODUCTS

A. Soil Treatment

1. Termiticide: Provide an EPA-Registered termiticide, complying with requirements of authorities having jurisdiction, in an aqueous solution formulated to prevent termite infestation. Provide quantity required for application at the label volume and rate for the maximum termiticide concentration allowed for each specific use, according to product's EPA-Registered Label.
  - a. Service Life of Treatment: Soil treatment termiticide that is effective for not less than three **OR five, as directed**, years against infestation of subterranean termites.

B. Wood Treatment

1. Borate: Provide an EPA-Registered borate termiticide, complying with requirements of authorities having jurisdiction, in an aqueous solution for spray application and a gel solution for pressure injection, formulated to prevent termite infestation in wood. Provide quantity required for application at the label volume and rate for the maximum diffusible borate concentration allowed for each specific use, according to product's EPA-Registered Label.

C. Bait-Station System

1. Provide bait stations based on the dimensions of building perimeter indicated on Drawings, according to manufacturer's EPA-Registered Label for product, manufacturer's written instructions, and the following:
  - a. No fewer than one bait station per **8 linear feet (2.4 linear meters) OR 20 linear feet (6.1 linear meters), as directed**.
  - b. No fewer than one cluster of bait stations per **20 linear feet (6.1 linear meters)**, consisting of no fewer than three bait stations per cluster.

D. Metal Mesh Barrier System

1. Stainless-Steel Mesh: **0.025-by-0.018-inch (0.64-by-0.45-mm)** mesh of **0.08-inch- (2.0-mm-)** diameter, stainless-steel wire, Type 316.

E. Polymer Sheet Barrier System

1. Polymer Sheet: **16-mil- (0.40-mm-)** thick, multilayered, laminated, polymer sheet with lambda-cyhalothrin termiticide sealed between two outer polymer layers.

F. Polymer Barrier Fittings

1. Pipe/Conduit Fitting: Integral **2-1/2-inch- (65-mm-)** long polymer sleeve and **1-inch- (25-mm-)** wide circular flange with lambda-cyhalothrin termiticide sealed between two outer polymer layers; with fasteners.
2. Tub Trap Fitting: Integral polymer boot and **23-by-23-inch (585-by-585-mm)** flange with lambda-cyhalothrin termiticide sealed between two outer polymer layers; with fasteners.



### 1.3 EXECUTION

#### A. Examination

1. Examine substrates, areas, and conditions, with Applicator present, for compliance with requirements for moisture content of soil per termiticide label requirements, interfaces with earthwork, slab and foundation work, landscaping, utility installation, and other conditions affecting performance of termite control.
2. Proceed with application only after unsatisfactory conditions have been corrected.

#### B. Preparation

1. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's written instructions for preparation before beginning application of termite control treatment. Remove all extraneous sources of wood cellulose and other edible materials such as wood debris, tree stumps and roots, stakes, formwork, and construction waste wood from soil within and around foundations.
2. Soil Treatment Preparation: Remove foreign matter and impermeable soil materials that could decrease treatment effectiveness on areas to be treated. Loosen, rake, and level soil to be treated except previously compacted areas under slabs and footings. Termiticides may be applied before placing compacted fill under slabs if recommended in writing by termiticide manufacturer.
  - a. Fit filling hose connected to water source at the site with a backflow preventer, complying with requirements of authorities having jurisdiction.

#### C. Application, General

1. General: Comply with the most stringent requirements of authorities having jurisdiction and with manufacturer's EPA-Registered Label for products.

#### D. Applying Soil Treatment

1. Application: Mix soil treatment termiticide solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of termiticide, according to manufacturer's EPA-Registered Label, to the following so that a continuous horizontal and vertical termiticidal barrier or treated zone is established around and under building construction. Distribute treatment evenly.
  - a. Slabs-on-Grade and Basement Slabs: Under ground-supported slab construction, including footings, building slabs, and attached slabs as an overall treatment. Treat soil materials before concrete footings and slabs are placed.
  - b. Foundations: Adjacent soil, including soil along the entire inside perimeter of foundation walls; along both sides of interior partition walls; around plumbing pipes and electric conduit penetrating the slab; around interior column footers, piers, and chimney bases; and along the entire outside perimeter, from grade to bottom of footing. Avoid soil washout around footings.
  - c. Crawlspace: Soil under and adjacent to foundations as previously indicated. Treat adjacent areas including around entrance platform, porches, and equipment bases. Apply overall treatment only where attached concrete platform and porches are on fill or ground.
  - d. Masonry: Treat voids.
  - e. Penetrations: At expansion joints, control joints, and areas where slabs will be penetrated.
2. Avoid disturbance of treated soil after application. Keep off treated areas until completely dry.
3. Protect termiticide solution, dispersed in treated soils and fills, from being diluted until ground-supported slabs are installed. Use waterproof barrier according to EPA-Registered Label instructions.
4. Post warning signs in areas of application.
5. Reapply soil treatment solution to areas disturbed by subsequent excavation, grading, landscaping, or other construction activities following application.

#### E. Applying Wood Treatment

1. Application: Mix wood treatment solution to a uniform consistency. Provide quantity required for application at the label volume and rate for the maximum specified concentration of borate, according to manufacturer's EPA-Registered Label, so that wood framing, sheathing, siding, and structural members subject to infestation receive treatment.
  - a. Framing and Sheathing: Apply termiticide solution by spray to bare wood for complete coverage.
  - b. Wood Members More Than **4 Inches (100 mm)** Thick: Inject termiticide gel solution under pressure into holes of size and spacing required by manufacturer for treatment.
  - c. Exterior Uncoated Wood Trim and Siding: Apply termiticide solution to bare wood siding. After 48 hours, apply a seal coat of paint as specified in Division 07.
- F. Installing Bait-Station System
  1. Place bait stations according to the EPA-Registered Label for the product and manufacturer's written instructions, in the following areas that are conducive to termite feeding and activity:
    - a. Conducive sites and locations indicated on Drawings.
    - b. In and around infested trees and stumps.
    - c. In mulch beds.
    - d. Where wood directly contacts soil.
    - e. Areas of high soil moisture.
    - f. Near irrigation sprinkler heads.
    - g. Each area where roof drainage system, including downspouts and scuppers, drains to soil.
    - h. Along driplines of roof overhangs without gutters.
    - i. Where condensate lines from mechanical equipment drip or drain to soil.
    - j. At plumbing penetrations through ground-supported slabs.
    - k. Other sites and locations as determined by licensed Installer.
  2. Inspect and service bait stations from time of their application until Final Completion unless extended by continuing service agreement, according to the EPA-Registered Label for product and manufacturer's written instructions for termite management system and bait products.
    - a. Service Frequency: Inspect bait stations not less than once every **OR** every three, **as directed**, month(s).
- G. Installing Metal Mesh Barrier System
  1. Install metal mesh barrier system where indicated to provide a continuous barrier to entry of subterranean termites according to manufacturer's written instructions.
    - a. Fit mesh tightly around pipe or other penetrations, and terminate at slab and foundation perimeters.
    - b. Install mesh under the perimeter of concrete slab edges and joints after vapor barrier and reinforcing steel are in place, and comply with manufacturer's written installation methods.
  2. Inspect annually for termite activity and effectiveness of metal mesh barrier system according to manufacturer's written instructions.
- H. Installing Polymer Sheet Barrier System
  1. Install polymer sheet barrier system according to manufacturer's EPA-Registered Label to provide a complete and continuous barrier to entry of subterranean termites.
  2. Remove any pipe wrap material so that the polymer sheet barrier system and fittings can be applied directly to the pipe or conduit. After installing the barrier, reapply pipe wrap material both below and above the blocker to protect the pipe from contact with concrete.
  3. Install polymer barrier fittings around each utility pipe and conduit penetrating concrete slab and/or foundation walls according to the EPA-Registered Label for the product and manufacturer's written instructions.
- I. Installing Polymer Barrier Fittings
  1. Remove any pipe wrap material so that the polymer barrier fittings can be applied directly to the pipe or conduit. After installing the barrier, reapply pipe wrap material both below and above the blocker to protect the pipe from contact with concrete.



2. Install polymer barrier fittings around each utility pipe and conduit penetrating concrete slab and/or foundation walls according to the EPA-Registered Label for the product and manufacturer's written instructions.

END OF SECTION 31 31 16 13

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## SECTION 31 31 19 13 - SOIL STERILIZATION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers soil sterilization. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations.

### 1.2 PRODUCTS

- A. Weed Eradication and Soil Fumigation: Products approved by the Environmental Protection Agency.
- B. Liquid and Dry Herbicides:
  1. Bare Ground Herbicides: Bromacil powder mixture or an ammonium sulfamate spray.
  2. Wetting Agents: As required.
- C. Equipment: Equipment shall be appropriate to the application and approved before use by the Owner.

### 1.3 EXECUTION

- A. Soil: After the subgrade has been prepared, all areas to be surfaced shall be treated with a weed eradicator and soil fumigant only in the designated areas.
- B. Wetting Agents may be used as an additive to improve the performance of weed and brush herbicides.

END OF SECTION 31 31 19 13

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## SECTION 31 32 13 16 - SOIL STABILIZATION-LIME

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers furnishing of materials and the preparation and production of a stabilized subgrade by the addition of hydrated lime to the native material.

### 1.2 PRODUCTS

#### A. Hydrated lime material requirements shall be as follows:

1. Available Lime Index as Calcium Hydroxide: 90 percent minimum.
2. Residue retained on No. 30 Sieve: 1 percent maximum.
3. Residue retained on No. 200 Sieve: 20 percent maximum.

### 1.3 EXECUTION:

- A. Preparation: Scarify the subgrade to the depth required and pulverize the material until it is substantially free of lumps greater than three inches in diameter.
- B. Installation: Lime shall be applied to the pulverized material as a slurry, unless otherwise directed. Water shall be added as needed to provide a moisture content of not less than 20 percent. Surface-applied lime slurry shall be plowed and/or disked into the soil as necessary. The resulting mixture shall be aged for not less than 48 hours before compaction.

END OF SECTION 31 32 13 16

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## SECTION 31 32 13 19 - SOIL STABILIZATION-VIBROFLOTATION

### 1.1 GENERAL

- A. This specification covers soil stabilization of sandy subsurfaces by the method of vibroflotation.

### 1.2 PRODUCTS - (Not Used)

### 1.3 EXECUTION

- A. The vibroflotation process shall be applied only to areas of clean, granular soils, with not over 20 percent silt or 10 percent clay. Vibrators shall be water-jetted into the soil mass to the depth required. The vibrator shall be withdrawn in 1 foot increments as the saturated soil compacts laterally and at a rate of approximately 1 ft/min to a minimum relative density of 70 percent. As the surface crater forms, sand or crushed rock shall be added and compacted to the appropriate line and grade. The horizontal distance between successive treatments shall not exceed 5 feet, or as directed.

END OF SECTION 31 32 13 19



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Task	Specification	Specification Description
31 32 13 19	31 32 13 16	Soil Stabilization-Lime
31 32 13 29	31 32 13 16	Soil Stabilization-Lime
31 32 19 13	31 32 13 16	Soil Stabilization-Lime
31 32 19 13	31 25 14 13	Geosynthetic Fabric

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## SECTION 31 32 19 16 - SEWAGE TREATMENT LAGOONS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for the repair and maintenance of sewage treatment lagoons. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Materials

1. Concrete Block shall comply with ASTM C 129.
2. Concrete Grout shall comply with Fed. Spec. MMM-A-001993.
3. Riprap Stone shall comply with AREA-01.
4. Concrete Repair Material shall comply with Fed. Spec. MMM-A-001993.
5. Sand shall comply with ASTM C 33.
6. Portland Cement shall comply with ASTM C 150, Type V.
7. Rubble shall consist of broken concrete or broken stone.

### 1.3 EXECUTION

- A. Algae Removal shall be by mechanical or manual methods and shall include, but not be limited to, skimming, pumping through a screen, raking, or draining and cleaning the lagoon.
- B. Slope and Dike Reconstruction shall be made to re-establish the original design configuration and grades. Place riprap, where required, so that its angle of repose is not exceeded.
- C. Liner Reconstruction and Repair shall be made with materials compatible with the existing liner and compatible with the wastewater and sludge to be contained therein.
- D. Repairs to Elastomeric Membrane Liners shall be made with like material and shall overlap all cuts, tears, fractures or other defects a minimum of 4 inches. Cut repair pieces square or rectangular. The method of bonding the new material to existing material shall be similar to the original joint banding method, except when the original joints have failed. In this case, the material supplier shall demonstrate that an alternate jointing system shall be satisfactory to the Owner. Replace earth or sand cover removed during repair or replacement of plastic liner to the same thickness as the original installation.
- E. Repairs to Non-Elastomeric Membrane Liners shall be made by cutting out defective areas back to sound liner material and replacing with similar material. Joints shall be watertight.

END OF SECTION 31 32 19 16

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## SECTION 31 32 19 16a - POND RESERVOIR LINERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for pond and reservoir liners. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes geomembrane liners and floating covers for ponds and reservoirs.

#### C. Definitions

1. Plastics Terminology: See ASTM D 1600 for definitions of abbreviated terms for plastics not otherwise defined in this Section.
2. CSPE: Chlorosulfonated polyethylene.
3. EIA: Ethylene interpolymer alloy.
4. EPDM: Ethylene-propylene-diene terpolymer.
5. PE: Polyethylene.
6. PP: Polypropylene.

#### D. Performance Requirements

1. Provide geomembrane liners and floating covers, **as directed**, that prevent the passage of water and gas, **as directed**.

#### E. Submittals

1. Product Data: For each type of product indicated. Include the following:
  - a. Sheets for geomembrane liners and floating covers.
  - b. Seaming adhesives, solvents, and extrusions.
  - c. Penetration assemblies.
  - d. Accessories for floating covers.
2. Shop Drawings: Show fabrication and installation details for geomembrane liners. Show panel layout, seams, penetrations, perimeter anchorage, floating cover, and methods of attachment and sealing to other construction. Differentiate between factory and field seams and joints.
3. Samples: For the following products, in sizes indicated:
  - a. Geomembrane Panels: For each type, not less than one **12-inch (300-mm)** seam length for factory-bonded sheets and one **12-inch (300-mm)** seam length for field-bonded sheets.
4. Qualification Data: For qualified Installer **OR** testing agency, **as directed**.
5. Product Certificates: For each type of geomembrane liner and floating cover, from manufacturer.
6. Product Test Reports: For each geomembrane sheet, based on evaluation of comprehensive tests performed by a qualified testing agency.
7. Source quality-control reports.
8. Field quality-control reports.
9. Maintenance Data: For geomembrane liner and floating cover to include in maintenance manuals.
10. Warranty: Special warranty specified in this Section.

#### F. Quality Assurance

1. Installer Qualifications: Fabricator of products **OR** An employer of workers trained and approved by manufacturer, **as directed**.
2. Source Limitations: Obtain geomembrane liner and floating cover, accessories, and required seaming materials, solvents, and adhesives from single source.
3. Preinstallation Conference: Conduct conference at Project site.

- a. Inspect and discuss condition of substrate and other preparatory work performed by other trades.
- b. Review structural load limitations.
- c. Review limitations on equipment and Installer's personnel.
- d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
- e. Review required testing, inspecting, and certifying procedures.
- f. Review existing and forecasted weather conditions and procedures for unfavorable conditions.

G. Project Conditions

1. Weather Limitations: Proceed with installation only when existing and forecasted weather conditions permit placement and seaming of geomembrane liners and floating covers to be performed according to manufacturers' written instructions and warranty requirements.

H. Warranty

1. Special Warranty: Specified form in which geomembrane manufacturer, geomembrane liner and floating cover fabricator, and geomembrane liner and floating cover Installer agree to repair or replace geomembrane liner and floating cover that fail(s) in materials or workmanship or that deteriorate(s) under conditions of normal weather within specified warranty period. Warranty does not include deterioration or failure of geomembrane liner and floating cover due to exposure to harmful chemicals, gases or vapors, abnormal and severe weather phenomena, fire, earthquakes, floods, vandalism, or abuse by persons, animals, or equipment.
  - a. Failures include, but are not limited to, the following:
    - 1) Leaks in geomembrane liner and floating cover.
    - 2) Defects in seams.
    - 3) Cracks and holes in floating cover.
  - b. Warranty Period: One **OR** Five **OR** 10, **as directed**, year(s) from date of Final Completion.

## 1.2 PRODUCTS

A. CSPE Sheet Materials

1. CSPE Sheet: Formulated from CSPE for use in hydraulic structures and formed into uniform, flexible sheets.
  - a. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
    - 1) Construction: 6 x 6 - 1000 d **OR** 8 x 8 - 250 d **OR** 10 x 10 - 1000 d, **as directed**.
  - b. Nominal Thickness: **45-mil- (1.14-mm-)** thick sheet per ASTM D 5199 or ASTM D 751, Optical Method.
  - c. Nominal Thickness over Scrim: **11-mil- (0.28-mm-)** thick sheet per ASTM D 5199 or ASTM D 751, Optical Method.
  - d. Breaking Strength: Not less than **200 lbf (0.89 kN)** minimum average per ASTM D 751, Procedure A.
  - e. Tear Strength, Initial: Not less than **70 lbf (0.31 kN)** minimum average per ASTM D 5884 or ASTM D 751, Procedure B.
  - f. Tear Strength, after Aging: Not less than **35 lbf (0.16 kN)** minimum average per ASTM D 5884 or ASTM D 751, Procedure B.
  - g. Puncture Resistance: Not less than **200 lbf (0.89 kN)** minimum average per ASTM D 4833.
  - h. Hydrostatic Resistance: Not less than **250-psi (1725-kPa)** minimum average resistance per ASTM D 5514, Procedure A or ASTM D 751, Method A, Procedure 1.
  - i. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 2 percent per ASTM D 1204.
  - j. Low-Temperature Flexibility: Pass, **1/8-inch (3-mm)** mandrel, four hours at **minus 40 deg F (minus 40 deg C)**, and per ASTM D 2136.

- k. UV-Light Resistance: Pass, 4000 hours at 176 deg F (80 deg C), per ASTM G 155.
- l. Ply Adhesion: Not less than 7 lbf/in. (1.2 kN/m) OR 10 lbf/in. (1.75 kN/m), as directed, of seam width, or film tearing bond, according to ASTM D 413, Machine Method.
- m. Water Absorption (for low-water-absorption CSPE): Not more than 2 percent at 70 deg F (21 deg C) and not more than 30 percent at 158 deg F (70 deg C) for 30 days each per ASTM D 471, 30-mil- (0.76-mm-) thick sheet.

B. EIA Sheet Materials

- 1. EIA Sheet: Formulated from EIA for use in hydraulic structures and formed into uniform, flexible sheets.
  - a. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
    - 1) Construction: 6 x 6 - 1000 d OR 8 x 8 - 500 d OR 10 x 10 - 1000 d OR 10 x 11 - 2520 d x 2000 d, as directed.
  - b. Nominal Thickness: 36-mil- (0.91-mm-) thick sheet per ASTM D 1593 or ASTM D 751, Optical Method.
  - c. Tensile Strength: Not less than 400 lbf (1.8 kN) minimum average per ASTM D 751, Procedure A.
  - d. Tear Strength: Not less than 35 lbf (0.16 kN) minimum average per ASTM D 5884 or ASTM D 751, Procedure B.
  - e. Puncture Resistance: Not less than 150 lbf (0.67 kN) minimum average per ASTM D 4833.
  - f. Hydrostatic Resistance: Not less than 100-psi (690-kPa) minimum average resistance per ASTM D 751, Procedure A.
  - g. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 2 percent per ASTM D 1204.
  - h. Low-Temperature Flexibility: Pass, 1/8-inch (3-mm) mandrel, four hours at minus 30 deg F (minus 34 deg C), and per ASTM D 2136.
  - i. UV-Light Resistance: Pass, 4000 hours at 176 deg F (80 deg C), per ASTM G 155.
  - j. Ply Adhesion: Not less than 7 lbf/in. (1.2 kN/m) OR 10 lbf/in. (1.75 kN/m), as directed, of seam width, or film tearing bond, according to ASTM D 413, Machine Method.

C. EPDM Sheet Materials

- 1. EPDM Sheet: Formulated from EPDM, compounded for use in hydraulic structures and formed into uniform, flexible sheets.
  - a. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
    - 1) Construction: 9 x 9 - 1000 d OR 10 x 10 - 1000 d, as directed.
  - b. Nominal Thickness: 45-mil- (1.14-mm-) thick sheet per ASTM D 5199 or ASTM D 751, Optical Method.
  - c. Breaking Strength: Not less than 190 lbf (0.85 kN) minimum average per ASTM D 882, ASTM D 7004, or ASTM D 751, Procedure A.
  - d. Tear Resistance: Not less than 130 lb (0.58 kN) minimum average per ASTM D 1004.
  - e. Puncture Strength: Not less than 60 lbf (0.27 kN) minimum average per ASTM D 4833.

D. PE Sheet Materials

- 1. PE Sheet: Formulated from virgin PE, compounded for use in hydraulic structures, and formed into uniform sheets.
  - a. Sheet Texture: One side smooth; other side smooth OR textured, as directed.
  - b. Nominal Density: Low density, 0.910 to 0.925 g/cu. cm OR Linear low density, 0.919 to 0.925 g/cu. cm OR Medium density, 0.926 to 0.939 g/cu. cm OR High density, 0.940 to 0.959 g/cu. cm, as directed, per ASTM D 1505.
  - c. Nominal Thickness: 60-mil- (1.5-mm-) thick sheet per ASTM D 5199 OR ASTM D 5994, as directed.
  - d. Melt Flow Index: Not more than 0.035 oz./10 minutes (1.0 g/10 minutes) per ASTM D 1238, Condition 190/2.16.
  - e. Carbon Black Content: 2 to 3 percent per ASTM D 1603 or ASTM D 4218.
  - f. Carbon Black Dispersion: Per ASTM D 5596, Category 1 and 2.



- g. Oxidation Induction Time: Not less than 100 minutes per ASTM D 3895.
- h. Tensile Properties: Not less than indicated for each direction, per ASTM D 638, Type IV or ASTM D 6693, Type IV.
  - 1) Strength at Yield: Not less than **126 lbf/in.** (22 kN/m) and **2100 psi** (14.5 MPa) minimum average.
  - 2) Strength at Break: Not less than **228 lbf/in.** (40 kN/m) and **3800 psi** (26.2 MPa) minimum average.
  - 3) Elongation at Yield: Not less than 12 percent minimum average.
  - 4) Elongation at Break: Not less than 700 percent minimum average.
- i. Tear Resistance: Not less than **39 lbf** (0.18 kN) minimum average per ASTM D 1004.
- j. Puncture Resistance: Not less than **108 lbf** (0.48 kN) minimum average per ASTM D 4833.
- k. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 2 percent per ASTM D 1204.
- l. Low-Temperature Brittleness: Four hours at **minus 76 deg F** (minus 60 deg C) per ASTM D 746.
- m. Environmental Stress Cracking Resistance: Not less than 1500 hours per ASTM D 1693, Condition B.

E. PP Sheet Materials

- 1. PP Sheet: Formulated from virgin PP, compounded for use in hydraulic structures, and formed into uniform, flexible sheets.
  - a. Reinforcing Scrim: One-ply polyester fabric totally encapsulated between two sheets.
    - 1) Construction: 9 x 9 - 1000 d **OR** 10 x 10 - 1000 d, **as directed**.
  - b. Sheet Texture: One side smooth; other side smooth **OR** textured, **as directed**.
  - c. Nominal Thickness: **45-mil-** (1.14-mm-) thick sheet per ASTM D 5199 or ASTM D 751, Optical Method **OR** ASTM D 5994, **as directed**.
  - d. Tensile Strength: Not less than **250 lbf** (1.1 kN) minimum average per ASTM D 412, ASTM D 7003, ASTM D 6693, or ASTM D 751, Procedure A.
  - e. Tear Resistance: Not less than **55 lbf** (0.24 kN) minimum average per ASTM D 1004, ASTM D 5884, ASTM D 7003, or ASTM D 751, Procedure B.
  - f. Puncture Resistance: Not less than **200 lbf** (0.88 kN) minimum average per ASTM D 4833 or ASTM D 7003.
  - g. Low-Temperature Flexibility: Pass, **1/8-inch** (3-mm) mandrel, four hours at **minus 40 deg F** (minus 40 deg C), and per ASTM D 2136.
  - h. Hydrostatic Resistance: Not less than **250-psi** (1725-kPa) minimum average resistance per ASTM D 5514, Procedure A or ASTM D 751, Method A, Procedure 1.
  - i. Dimensional Stability, Reinforced Sheet: Not more than plus or minus 1 percent per ASTM D 1204.
  - j. Ply Adhesion: Not less than **20 lbf/in.** (3.5 kN/m) of seam width, or film tearing bond, according to ASTM D 413, Machine Method.

F. PVC Sheet Materials

- 1. PVC Sheet: Formulated from virgin PVC with plasticizers and other modifiers, compounded for use in hydraulic structures, and formed into uniform, flexible sheets with material properties complying with ASTM D 7176 **OR** PGI 1104, "Specification for PVC Geomembranes", **as directed**, for nominal thickness indicated.
  - a. Nominal Thickness: **10 mils** (0.25 mm) **OR** **20 mils** (0.51 mm) **OR** **30 mils** (0.76 mm) **OR** **40 mils** (1.02 mm) **OR** **50 mils** (1.3 mm) **OR** **60 mils** (1.5 mm), **as directed**.
  - b. Sheet Texture: One side smooth; other side smooth **OR** matte **OR** faille textured, **as directed**.

G. Floating Cover Accessories

- 1. Screened Scupper Hoses: Manufacturer's standard.

2. Flotation Blocks: Closed-cell polyethylene foam blocks approximately **4 by 12 inches** (**102 by 300 mm**), **2.2 lb/cu. ft.** (**35.2 kg/cu. m**).
3. Access Hatch: Manufacturer's standard, in size indicated.

#### H. Miscellaneous Materials

1. Adhesives: Provide types of adhesive primers, compounds, solvents, and tapes recommended in writing by geomembrane liner manufacturer for bonding to structures (if required), for sealing of seams in geomembrane liner, and for sealing penetrations through geomembrane liner.
2. Penetration Assemblies: Provide manufacturer's standard factory-fabricated assemblies for sealing penetrations. Include joint sealant recommended in writing by geomembrane liner manufacturer and compatible with geomembrane liner, containment conditions, and materials.
3. Battens: Long-length strips of material indicated, size as shown on Drawings. Fabricate battens with sharp projections removed and edges eased and then predrilled or punched for anchors. Provide anchors, or other type of attachment, of type and spacing recommended in writing by geomembrane liner manufacturer for attaching geomembrane liner system to substrate and as indicated.
  - a. Batten Material: Liner manufacturer's standard system.  
**OR**  
 Batten Material: Aluminum; with stainless-steel anchors, complete with gasket and sealant compatible with geomembrane liner, containment conditions, and materials.  
**OR**  
 Batten Material: Stainless steel; with stainless-steel anchors, complete with gasket and sealant compatible with geomembrane liner, containment conditions, and materials.  
**OR**  
 Batten Material: Plastic compatible with geomembrane liner, cast in place or fastened with stainless-steel anchors, designed to continuously seal geomembrane liner to batten.
4. Sand: ASTM C 33; fine aggregate, natural or manufactured sand.

#### I. Fabrication

1. Fabricate geomembrane liner and floating cover, **as directed**, panels from sheets in sizes as large as possible with factory-sealed seams, consistent with limitations of weight and installation procedures. Minimize field seaming.
2. Fabricate flotation blocks, wrap in geomembrane, and attach to underside of floating cover according to manufacturer's written instructions.
3. Fabricate ballast tubes of sand-filled geomembrane and attach to top surface of floating cover according to manufacturer's written instructions.
4. Install built-in accessories, hatches, access panels, vents, and walkways on geomembrane floating cover.

#### J. Source Quality Control

1. Testing Agency: Engage a qualified testing agency to evaluate geomembrane seams.
2. Destructive Testing: Test for bonded seam strength and peel adhesion every **3000 feet** (**915 m**) or once per panel, whichever is more frequent.
3. CSPE Liner and Floating Cover: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than **10 lbf/in.** (**1.75 kN/m**) of seam width and for bonded seam strength not less than **180 lbf/in.** (**32 kN/m**) of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than **45 mils** (**1.14 mm**).
4. EIA Liner and Floating Cover: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than **10 lbf/in.** (**1.75 kN/m**) of seam width and for bonded seam strength not less than **270 lbf/in.** (**48 kN/m**) of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than **36 mils** (**0.91 mm**).
5. EPDM Liner: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than **10 lbf/in.** (**1.75 kN/m**) of seam width and for bonded seam strength not less than **160 lbf/in.** (**28 kN/m**) of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than **45 mils** (**1.14 mm**).

6. PE Liner: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion and for bonded seam strength indicated.
  - a. Peel Adhesion/Extrusion: Film tear bond and not less than **78 lbf/in. (13.7 kN/m)** of extrusion-bonded seam width.  
**OR**  
Peel Adhesion/Fusion: Film tear bond and not less than **90 lbf/in. (15.8 kN/m)** of fused seam width.
  - b. Bonded Seam Strength: Not less than **120 lbf/in. (21 kN/m)** of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than **45 mils (1.14 mm)**.
7. PP Liner and Floating Cover: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than **20 lbf/in. (3.5 kN/m)** of seam width and for bonded seam strength not less than **200 lbf/in. (35 kN/m)** of seam width for seams constructed from two scrim-reinforced sheets, each with nominal sheet thickness of not less than **45 mils (1.14 mm)**.
8. PVC Liner and Floating Cover: Test and inspect factory seams, according to ASTM D 4545, for peel adhesion not less than **10 lbf/in. (1.75 kN/m)** of seam width and for bonded seam strength not less than that indicated below for seams constructed from two sheets of minimum nominal thickness indicated for each:
  - a. Bonded Seam Strength for **10-mil- (0.25-mm-)** Thick Sheets: **20 lbf/in. (3.5 kN/m)** of seam width.
  - b. Bonded Seam Strength for **20-mil- (0.51-mm-)** Thick Sheets: **38.5 lbf/in. (6.7 kN/m)** of seam width.
  - c. Bonded Seam Strength for **30-mil- (0.76-mm-)** Thick Sheets: **58.4 lbf/in. (10.2 kN/m)** of seam width.
  - d. Bonded Seam Strength for **40-mil- (1.02-mm-)** Thick Sheets: **77.6 lbf/in. (13.6 kN/m)** of seam width.
  - e. Bonded Seam Strength for **50-mil- (1.3-mm-)** Thick Sheets: **96 lbf/in. (16.8 kN/m)** of seam width.
  - f. Bonded Seam Strength for **60-mil- (1.5-mm-)** Thick Sheets: **116 lbf/in. (20.3 kN/m)** of seam width.

### 1.3 EXECUTION

#### A. Examination

1. Examine substrates, with Installer present, for compliance with requirements for soil compaction and grading; for subgrade free from angular rocks, rubble, roots, vegetation, debris, voids, protrusions, and ground water; and for other conditions affecting performance of geomembrane liner.
2. Examine anchor trench excavation **OR** concrete perimeter, **as directed**, where geomembrane liner and floating cover, **as directed**, will be secured, for substrate conditions indicated above and for correct location and configuration.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Preparation

1. Provide temporary ballast, until edges are permanently secured, that does not damage geomembrane liner or substrate, to prevent uplift of geomembrane liner in areas with prevailing winds.
2. Prepare surfaces of construction penetrating through geomembrane liner according to geomembrane liner manufacturer's written instructions.
3. Remove curing compounds and coatings from concrete surfaces to be sealed to geomembrane liner.

#### C. Installation

1. General: Place geomembrane liner over prepared surfaces to ensure minimum handling. Install according to Shop Drawings and in compliance with geomembrane liner manufacturer's written instructions. Begin placing geomembrane liner at Project's upwind direction and proceed downwind. Install geomembrane liner in a relaxed condition, free from stress and with minimum wrinkles, and in full contact with subgrade. Do not bridge over voids or low areas in the subgrade. Fit closely and seal around inlets, outlets, and other projections through geomembrane liner. Permanently secure edges.
  2. Field Seams: Comply with geomembrane liner and floating cover manufacturer's written instructions. Form seams by lapping edges of panels **2 to 4 inches (50 to 102 mm)** unless instructions require a larger overlap. Wipe contact surfaces clean and free of dirt, dust, moisture, and other foreign materials. Use solvent-cleaning methods and grind geomembrane seam surfaces if recommended by geomembrane liner manufacturer. Proceed with seaming at required temperatures for materials and ambient conditions. Continuously bond sheet to sheet to construct single or double seams of width recommended for method of seaming used. Seal or fuse free seam edges. Inspect seams and reseal voids.
    - a. Adhesive Bonding: Apply bonding cement to both contact surfaces in seam area and press together immediately, or use other seaming methods as instructed by geomembrane liner manufacturer. Roll to press surfaces together, to distribute adhesive to leading edges of panels, and to remove wrinkles and fishmouths. Remove excess adhesive.
    - OR**
    - Thermal Bonding: Use thermal-welding technique recommended by geomembrane liner manufacturer. Apply pressure to smoothly bond surfaces together. Examine for and patch wrinkles and fishmouths.
  3. Installation in Anchor Trench: Install geomembrane liner and floating cover in trench according to manufacturer's written instructions. Backfill and compact to lock liner into trench.
  4. Attachment to Concrete: Use manufacturer's standard system to suit Project conditions. Support adhesive and geomembrane on minimum **8-inch- (200-mm-)** wide concrete substrate unless otherwise indicated.
    - a. Install batten strips over geomembrane liner and floating cover as shown on Drawings.
    - b. Install antichafing strips of geomembrane sheet between geomembrane liner and floating cover according to manufacturer's written instructions.
    - c. Install floating cover with perimeter fold.
  5. Floating Cover Flotation Control: Connect drainage hoses in perimeter fold, sumps, or scuppers to pump or gravity drain system.
  6. Liner Repairs: Repair tears, punctures, and other imperfections in geomembrane liner field and seams using patches of geomembrane liner material, liner-to-liner bonding materials, and bonding methods according to geomembrane liner manufacturer's written instructions. Apply bonding solvent or weld to contact surfaces of both patch and geomembrane liner, and press together immediately. Roll to remove wrinkles.
- D. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
  2. Nondestructive Testing: Visually inspect seams and patches. Comply with ASTM D 4437 for Air Lance Test, Vacuum Box Testing, or Ultrasonic (High Frequency) Pulse Echo Testing or with GRI Test Method GM6, as applicable to geomembrane liner and floating cover and seam construction. Record locations of failed seams and patches. Individually number and date occurrences and details of leak and remedial action. Repair leaking seams and patches.
  3. Prepare test and inspection reports.
- E. Disinfection
1. Disinfect the complete installation according to procedures in AWWA C652.
- F. Protection
1. Protect installed geomembrane liner and floating cover according to manufacturer's written instructions. Repair or replace areas of geomembrane liner damaged by scuffing, punctures, traffic, rough subgrade, or other unacceptable conditions.



2. Before initial filling of pond or placement of earth cover, inspect seams and patched areas to ensure tight, continuously bonded installation. Repair damaged geomembrane and seams and reinspect repaired work.

END OF SECTION 31 32 19 16a

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Task	Specification	Specification Description
31 32 19 16	21 05 23 00	Piped Utilities Basic Materials And Methods
31 32 19 16	31 32 13 16	Soil Stabilization-Lime
31 32 19 16	31 25 14 13	Geosynthetic Fabric

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## SECTION 31 36 13 00 - WIRE MESH GABIONS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of wire mesh gabions. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

- B. Description: Gabion units shall consist of compartmented rectangular basket containers filled with stone. The required sizes of the gabion units are Length times Width times Depth. Twisted or welded wire mesh shall be used. Baskets shall be fabricated from galvanized steel wire formed into a nonraveling mesh.

#### C. Submittals

1. Samples: Stone fill material submitted for approval prior to delivery.

### 1.2 PRODUCTS

- A. Steel Twisted Wire Mesh Gabions: Gabion basket units shall be of nonraveling construction and fabricated from a double twisted hexagonal wire mesh. The size of mesh openings shall be approximately 3-1/4 in. by 4-1/2 in. (80 by 115 mm). The gabion mesh wires shall be wrapped around the selva wire no less than 1 1/2 times and shall interconnect with adjacent mesh wires. All steel wire used shall be galvanized prior to fabrication into mesh. All gabion diaphragm and frame wire shall equal or exceed ASTM A 641, and possess soft tensile strength of 60,000 psi (415 Mpa) with a tolerance of minus 2,000 psi (14 Mpa). The galvanized wire shall have a Finish 5, Class 3, zinc coating, as indicated in ASTM A 641. The weight of coating shall be determined by ASTM A 90. The grade of zinc used for coating shall be High Grade or Special High Grade as prescribed in ASTM B 6, Table 1. The uniformity of coating shall equal or exceed four 1-minute dips by the Preece Test, as determined by ASTM A 239.
- B. Steel Welded Wire Mesh Gabions: Gabion basket units shall be of nonraveling construction and fabricated from a welded square wire mesh. The size of mesh openings shall be approximately 3 in. by 3 in. (75 by 75 mm). The welded joints of the wire mesh shall conform to ASTM A 1064 except that the weld shears shall be at least 600 lbs (2700 N). All gabion diaphragm and frame wire shall equal or exceed ASTM A 641, and possess soft tensile strength of 60,000 psi (415 Mpa) with a tolerance of minus 2,000 psi (14 Mpa). The galvanized wire shall have a Finish 5 Class 3 zinc coating, indicated in ASTM A 641. The weight of coating shall be determined by ASTM A 90. The grade of zinc used for coating shall be High Grade or Special High Grade as prescribed in ASTM B 6, Table 1. The uniformity of coating shall equal or exceed four 1-minute dips by the Preece Test, as determined by ASTM A 239.
- C. Mesh wire shall be minimum 0.120-in. (3.05 mm) diameter after coating with 0.85 oz/sq ft (240 g/sq m) zinc coating.
- D. Selva wire shall be minimum 0.150-in. (3.80 mm) diameter after coating with 0.85 oz/sq ft (240 g/sq m) zinc coating.
- E. Wire used for lacing or as internal connecting wire within basket cells shall be minimum 0.087-in. (2.21 mm) diameter after coating with 0.70 oz/sq ft (220 g/sq m) zinc coating and may have soft tensile strength designation.
- F. Stone Fill



1. **Quality:** Stone shall be durable and of suitable quality to ensure permanence in the structure and climate in which it is to be used. It shall be free of cracks, seams, and other defects that would tend to increase unduly its deterioration from natural causes or reduce its size to that which could not be retained in the gabion baskets. The inclusion of more than 5% by weight of dirt, sand, clay, and rock fines will not be permitted. The sources from which the Contractor proposes to obtain the material shall be selected well in advance of the time when the material will be required in the work. Suitable samples of stone fill material shall be collected in the presence of the Owner's representative and submitted to the Owner for approval prior to delivery of any such material to the site of the work. Unless otherwise specified, all test samples shall be obtained by the Contractor and delivered at its expense to the Owner. Suitable tests and/or service records will be used to determine the acceptability of the stone. In the event suitable test reports and service records are not available, the material shall be subjected to such tests as are necessary to determine its acceptability for use in the work. Tests to which the material may be subjected include petrographic analysis, specific gravity, absorption, wetting and drying, freezing and thawing, and such other tests as may be considered necessary to demonstrate to the satisfaction of the Owner that the materials are acceptable for use in the work.
2. **Gradation:** Stone fill used in the gabions shall be a well-graded mixture with sizes ranging between **4 in. and 8 in. (100 and 200 mm)**, based on US Standard square mesh sieves. No stone shall have a minimum dimension less than **4 in. (100 mm)** and a maximum dimension greater than **12 in. (300 mm)** in any direction. The ratio of the maximum dimension to the minimum dimension shall not be greater than two. If the height of the gabion basket is **12 in. (300 mm)** or less, stone shall have no dimensions greater than **8 in. (200 mm)** in any direction.
3. **Filter Material:** The material shall be composed of tough durable particles, reasonably free from thin, flat, and elongated pieces, and contain no organic matter or soft friable particles in quantities considered objectionable by the Owner. Filter material shall consist of sand and gravel or crushed stone, well graded between the prescribed limits listed below, and conform to the requirements of paragraph STONE FILL, subparagraph QUALITY as to quality.

### 1.3 EXECUTION:

- A. **Foundation Preparation:** No foundation preparation work shall take place on frozen or snow-covered ground. After excavation or stripping to the extent indicated on the drawings or as directed by the Owner, all remaining loose or otherwise unsuitable materials shall be removed. All depressions shall be carefully backfilled to grade. If pervious materials are encountered in the foundation depressions, the areas shall be backfilled with free-draining materials. Otherwise, the depressions shall be backfilled with suitable materials from adjacent required excavation, or other approved source, and compacted to a density at least equal to that of the adjacent foundation. Any buried debris protruding from the foundation that will impede the proper installation and final appearance of the gabion layer shall also be removed, and the voids carefully backfilled and compacted as specified above. Immediately prior to placing the material, the prepared foundation surface shall be inspected by the Owner, and no material shall be placed thereon until that area has been approved.
- B. **Filter Placement:** Filter material shall be spread uniformly on the prepared foundation surface in a manner satisfactory to the Owner, and to the slopes, lines, and grades as indicated on the drawings or as directed. Placing of filter material by methods which will tend to segregate particle sizes will not be permitted. Any damage to the foundation surface during filter placement shall be repaired before proceeding with the work. Compaction of the filter materials will not be required, but it shall be finished to present a reasonably even surface free from mounds or windrows.
- C. **Fabrication:** Gabions shall be fabricated in such a manner that the sides, ends, lid, and diaphragms can be assembled at the construction site into rectangular baskets of the sizes specified and shown on the drawings. Gabions shall be of single unit construction, i.e., the base, lid, ends, and sides shall be either woven into a single unit, or one edge of these members connected to the base section of the gabion in such a manner that the minimum strengths of the wire mesh and connections as stated in paragraph

MATERIALS are met. Where the length of the gabion exceeds one and one-half its horizontal width, the gabion shall be equally divided by diaphragms of the same mesh and gage as the body of the gabions, into cells whose length does not exceed the horizontal width. The gabion shall be furnished with the necessary diaphragms secured in proper position on the base in such a manner that no additional tying at this juncture will be necessary. For twisted wire gabions, all perimeter edges of the mesh forming the gabion shall be securely selvaged. In addition, the selvaged edges shall be so wrapped and reinforced with the mesh ends that the selva ge wire will not be deformed locally about the lacing wire or wire fasteners when baskets are filled or during lid closing. Lacing wire, connecting wire, and/or wire fasteners shall be supplied in sufficient quantity for securely fastening all diaphragms and edges of the gabion.

- D. Assembly And Installation: For gabion units in excess of 4 ft. (1.3 m) in thickness, and placed in horizontal or near horizontal position to resist high velocity flow, or as part of a stilling basin feature, a minimum of two uniformly spaced vertical connecting wires per cell linking the foundation mesh to basket lid mesh should be specified. Empty gabion units shall be assembled individually and placed on the approved surface with the sides, ends, and diaphragms erected in such a manner to ensure the correct position of all creases and that the tops of all sides are level. Filling of gabion units in one place and then transporting them to their final position in the work will not be permitted. The front row of gabion units shall be placed first and successively constructed toward the top of the slope or the back of the structure. All gabion units shall be properly staggered horizontally and vertically. Finished gabion structure shall have no gaps along the perimeter of the contact surfaces between adjoining gabion basket units. All adjoining empty gabion units shall be connected by lacing wire/or wire fasteners along the perimeter of their contact surfaces in order to obtain a monolithic structure. Lacing of adjoining basket units shall be accomplished by continuous stitching with alternating single and double loops at intervals of not more than 5 in. (125 mm), and a half hitch shall be included at every double loop. All lacing wire terminals shall be securely fastened. Wire fasteners may be used in lieu of lacing wire for forming individual baskets and joining empty baskets together prior to stone filling. All joining shall be made through selva ge-to-selva ge or selva ge-to-edge wire connection; mesh-to-mesh or selva ge-to-mesh wire connection is prohibited except in the case where baskets are offset or stacked and selva ge-to-mesh or mesh-to-mesh wire connection would be necessary. Wire fasteners shall not be used to tie or join stone-filled baskets, unless approved by the Owner. As a minimum, a fastener shall be installed at each mesh opening at the location where mesh wire meets selva ge or edge wire. The initial line of basket units shall be placed on the prepared filter layer surface and partially filled to provide anchorage against deformation and displacement during filling operations. After adjoining empty basket units are set to line and grade and common sides with adjacent units thoroughly laced or fastened, they shall be placed in tension and stretched to remove any kinks from the mesh and to a uniform alignment. The stretching of empty basket units shall be accomplished in such a manner as to prevent any possible unraveling. Stone filling operations shall carefully proceed with placement by hand or machine so as not to damage galvanized wire coating, to assure a minimum of voids between the stones, and the maintenance of alignment throughout the filling process. Undue deformation and bulging of the mesh shall be corrected prior to further stone filling. To avoid localized deformation, the basket units in any row are to be filled in stages consisting of maximum 12-in. (300 mm) courses, and at no time shall any cell be filled to a depth exceeding 1 ft. (300 mm) more than the adjoining cell. The maximum height from which the stone may be dropped into the basket units shall be 36 in. (1 m). For gabion units in excess of 2 ft. (0.67 m) in height, two uniformly spaced internal connecting wires shall be placed between each stone layer in all front and side gabion units, connecting the back and the front faces of the compartments. Connecting wires or alternatively the preformed stiffeners shall be looped around two twisted wire mesh openings or a welded wire joint at each basket face and the wire terminals shall be securely twisted to prevent their loosening. For twisted wire gabions, the internal connecting wires or preformed stiffeners are installed. For welded wire gabion units, preformed stiffeners are installed across the corners of gabion panels. Along all exposed faces, the outer layer of stone shall be carefully placed and arranged by hand to ensure a neat and compact appearance. The last layer of stone shall be uniformly overfilled 1 to 2 in. (25 to 50 mm) to compensate for the future settlement in rock but still allow for the proper closing of the lid and to provide an even surface that is uniform in appearance. Final adjustments for compaction and surface tolerance shall be done by hand. Lids shall be stretched tight over the stone fill using only an approved lid closing tool, until the lid meets the perimeter edges of



the front and end panels. Using crowbars or other single point leverage bars for lid closing shall be prohibited. The lid shall then be tightly tied with lacing wire, or with wire fasteners if approved by the Owner, along all edges, ends, and internal cell diaphragms by continuous stitching with alternating single and double loops at intervals of not more than 5 in. (125 mm), and a half hitch shall be included at every double loop. Special attention shall be given to see that all projections or wire ends are turned into the baskets. The Contractor shall have the option of providing gabion baskets with separate roll-out lids for the slope baskets. Roll-out lids shall be fabricated of the same material as the basket units and shall be furnished in widths as required for the contract work. as directed by the Owner, or where a complete gabion unit cannot be installed because of space limitations, the basket unit shall be cut, folded, and wired together to suit existing site conditions. The mesh must be cleanly cut and the surplus mesh cut out completely, or folded back and neatly wired to an adjacent gabion face. The assembling, installation, filling, lid closing, and lacing of the reshaped gabion units shall be carried out as specified above.

END OF SECTION 31 36 13 00

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## SECTION 31 37 13 00 - RIPRAP

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of riprap. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Demolition and removal of materials shall be as required to support the work.

### 1.2 PRODUCTS

- A. Riprap: Stone used for dumped riprap shall be hard, durable, angular in shape, resistant to weathering and to water action, and free from overburden, spoil, shale, and organic material. Neither width nor thickness of a single stone should be less than one third its length. Rounded stone, boulders, shale, and stone with shale seams will not be acceptable. The minimum density of the riprap material shall be 162 pounds per cubic foot. Each load of riprap shall be reasonably well graded. Sand and rock dust exceeding 5 percent by weight of each load shall not be permitted.
- B. Riprap Bedding: The riprap bedding blanket shall consist of well graded gravel, crushed rock, sand, or a combination thereof with a maximum size of 6 inches. All material comprising the riprap bedding blanket shall be composed of tough, durable particles, reasonably free from thin, flat, and elongated pieces, and shall contain no organic matter nor soft, friable particles in excess quantities.

### 1.3 EXECUTION

- A. Preparation: Prepare earth slopes by grading and compacting.
- B. Installation:
  1. Riprap Bedding Blanket Layers shall be placed on the prepared slope or area to develop the full thickness. Each layer shall be placed in one operation, using methods that will not cause segregation of particle sizes within the bedding. The surface of the finished layer should be reasonably even and free from mounds or windows.
  2. Stone for Riprap shall be placed on the prepared slope or area in a manner that will product a reasonably well-graded mass of stone with the minimum practicable percentage of voids. Riprap shall be placed to its full course in one operation and in such a manner as to avoid displacing the underlying material. The larger stones shall be well distributed and the entire mass of stone shall be well-graded. The result shall be a compact, uniform riprap layer.

END OF SECTION 31 37 13 00

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Task	Specification	Specification Description
31 37 13 00	01 22 16 00	No Specification Required
31 37 13 00	31 32 19 16	Sewage Treatment Lagoons
31 41 16 13	31 23 16 13	Excavation Support And Protection
31 45 13 00	31 32 13 19	Soil Stabilization-Vibroflotation

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## SECTION 31 62 13 23 - PRESTRESSED CONCRETE PILES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for relief wells. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Shop Drawings: Submit shop drawings.
2. Statements
  - a. Before installation, all well screen shall be approved.
  - b. The filter pack material and its gradation shall be approved before it is placed.
  - c. Submit the cement grout mixture proportion to be used in plugging abandoned wells.
3. Reports: Submit sampling and testing reports for each relief well, logs of the borings, well screen and riser pipe, backfill material, and pump tests. Register each well with the state as required by the state in which the well is installed.

- #### C. Regulatory Requirements:
- The state statutory and regulatory requirements form a part of this specification.

### 1.2 PRODUCTS

- #### A. Well Screen:
- The Contractor may, at its option, furnish and install well screen of any of the alternate types specified. The clear inside diameter of the screen shall be as directed by the Owner. Screen openings shall be uniform in size and pattern, and shall be spaced approximately equally around the circumference of the pipe.

1. PVC Pipe Screen: Pipe, fittings, and screen shall be of the size and types specified. Pipe, fittings, and screen shall conform to ASTM D 1784, ASTM D 1785, ASTM D 2466, or ASTM D 2467. All joints in the PVC pipe shall include couplings and shall be glued with a solvent cement conforming to ASTM D 2564. The PVC pipe strength properties shall be equivalent to PVC 1120 Schedule 40 **OR** 80, **as directed**, unthreaded plastic pipe.
  - a. Couplings: Couplings shall be bonded socket **OR** threaded, **OR** certilock, **as directed**, type. Fittings shall be produced of the same material and equal quality as specified for plastic pipe screen. Socket type fitting connections of pipe sections shall be bonded with solvent cement. The determination of the proportions and preparation of adhesives, the method of application, and the procedure used for making and curing the connections shall be the responsibility of the Contractor. The system for making joints at the relief well site shall provide a curing period adequate to develop the ultimate strength of the solvent cement. Self-tapping screws or other devices for holding pipe in the couplings during the setting period may be utilized as long as the screws do not penetrate the inside of the pipe. In no case shall a newly-made joint in the casing be stressed, lowered into the relief well, or be submerged in water prior to complete curing of the solvent cement adhesive.
  - b. Perforations: The PVC well screen shall be mill slot **OR** continuous wire wrapped rod base **OR** continuous wire wrapped rod base on perforated pipe **OR** continuous wire wrapped on perforated pipe screen **OR** similar to that manufactured by Johnson Well Equipment, Inc., Pensacola, FL, telephone (904) 453-3131, **as directed**. All well screen shall have smooth, sharp-edged openings free of burns, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.





2. **Fiberglass Pipe Screen:** Fiberglass pipe screen and fittings shall be manufactured from thermosetting epoxy resins and glass fiber by either a centrifugal casting process or by a filament winding process. Glass fiber used shall be continuous filament, electrical glass with a finish compatible with epoxy resins. Each glass fiber or filament shall be thoroughly impregnated with epoxy resin. Fiberglass pipe wall thickness, strength and durability requirements shall be equivalent to the Fiberglass/Epoxy pipe produced by Fiberglass Resources Corporation of Farmingdale, New York or Burgess Well Company, Inc., Minden, Nebraska, telephone (308) 832-1642. All fiberglass pipe and fittings shall be round and straight, of uniform quality and workmanship, and free from all defects including indentation, delamination, bends, cracks, blisters, porosity, dry spots, resin segregation and resin-starved areas. The inside of the pipe and fittings shall be smooth and uniform. The impregnation of the glass fiber with resin shall be such that when the pipe is cut or slotted, no fraying or looseness of glass fiber occurs.
  - a. **Couplings:** Couplings for fiberglass pipe sections shall be socket threaded or mechanical key-type couplings. The couplings shall be manufactured of the same materials used for the fiberglass pipe specified herein and may be either cast integrally with the pipe sections or as separate components for attachment to the pipe in the manufacturers plant. Key-type couplings shall consist of male and female halves designed for joining and locking together by means of a key strip inserted in grooves in the coupling halves. The minimum wall thickness remaining at any grooved section shall not be less than the minimum thickness specified for pipe. Key strips and locking strips shall be of fiberglass, plastic or other non-corrosive material capable of withstanding shearing and bearing stresses equivalent to the design load for the coupling. Socket type fitting connections of the pipe sections shall be bonded with epoxy adhesive. The epoxy materials and bonding agents shall be as recommended by the pipe manufacturer. Self-tapping screws or other devices for holding adhesive-joined pipe in the couplings during the curing period may be utilized. In no case shall a newly-made joint in the casing pipe be lowered into the relief well, or be submerged in water prior to complete curing of the adhesive.
  - b. **Perforations:** All fiberglass well screen shall be mill slot **OR** continuous wire wrapped rod base, **as directed**. All relief well screen shall have smooth, sharp-edged openings free of burrs, chipped edges, or broken areas on the interior and exterior surfaces of the pipe. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe.
3. **Steel Pipe Screen:** Steel well screen shall consist of perforated or slotted sections of steel pipe conforming to the requirements of ASTM A 53.
  - a. **Couplings:** Couplings for steel pipe screen shall be welded joints or threaded couplings. Welding shall be performed in accordance with requirements in ASME B31.9. Couplings shall meet the material requirements specified for steel pipe screen, except perforations shall be omitted. All threaded pipe and fittings shall be threaded in accordance with ASME B1.20.1. All threaded pipe sections may be field connected. Couplings shall be given the same protection against corrosion as specified for the well screen pipe. Protective coatings damaged while making couplings shall have the areas recoated.
  - b. **Perforations:** All steel pipe to be used as relief well screen shall be provided with perforations which shall consist of either machine-cut slots; drilled or punched openings. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe and shall be oriented with the length of the slot parallel to, normal to, or diagonal with the axis of the pipe. The pattern of the openings shall be uniformly spaced around the periphery of the pipe.
4. **Stainless Steel Well Screen:** The perforated well screen and fittings shall be fabricated entirely from stainless steel conforming to ASTM A 312/A 312M, Type 304, 304-L, 316 or 316-L. The well screen shall be of stainless steel with a keystone wire-wrapped continuous slot strainer equivalent to that manufactured by Howard Smith Screen Company, Houston, TX, telephone (713) 869-5771 or Johnson Screens, St. Paul, MN 55164, telephone (612) 636-3900.
  - a. **Couplings:** Couplings for the stainless steel well screen shall consist of the same material as the well screen and shall be threaded, flanged, and/or fitted with a welding ring. The

couplings shall conform in design to the couplings recommended by the manufacturer of the well screen.

- b. Tailpipe for Well Screen: The tailpipe for each well screen shall be made of the same material and at least the same minimum thickness as the riser pipe and shall include a bottom plug.
- B. Riser Pipe: The relief well riser pipe material and method of manufacture shall conform to the requirements specified in paragraph WELL SCREEN, except that the screen perforations or opening shall be omitted. The relief well riser pipe diameter and discharge details shall be as directed. Couplings to the well screen and between riser pipe sections shall be as specified in paragraph COUPLING.
- C. Filter Pack: Material for the filter pack around the riser pipes and screens shall be a washed grave, **OR** washed sand **OR** dry processed sand, **as directed**, composed of hard, tough, and durable particles free from adherent coating. The filter pack shall not be crushed stone. The filter pack material shall contain no detrimental quantities of organic matter nor soft, friable, thin, or elongated particles in accordance with the quality requirements in ASTM C 33, Table 1 and Table 3, Class 5S, and in ASTM E 11, Table 1.
- D. Outlet For Relief Well: Check Valve.
  1. The check valve shall be a one piece reinforced all rubber (neoprene) check valve with an integral elastomer flange similar and equal to the Red Valve Series 35, manufactured by Red Valve Company, Inc., 700 North Bell Ave., Pittsburgh, PA 15106, telephone (412) 279-0044. The backup ring for the check valve shall be stainless steel. Stainless steel bolts, washers, and nuts shall be used to fasten the valves onto the flanged end of the pipes. The check valve shall be installed with the flared end duck bill in a vertical position.  
**OR**  
Fabricate check valves of brass **OR** stainless steel **OR** aluminum, **as directed**, plate, threaded fasteners and rods. Fabricate sealing disc of silicone sponge rubber free of porous areas, foreign materials, and visible defects.
  2. Workmanship and metalwork fabrication of check valves shall be as directed. Install check valves accurately vertically and adjust to the required elevation.
- E. Concrete: Concrete shall conform to the requirements specified in Division 03 Section "Cast-in-place Concrete".

### 1.3 EXECUTION

- A. Drilling: Wells may be drilled by the reverse rotary circulation method or other method approved, which will ensure proper placement of the well screen, riser pipe, and filter pack. Methods which involve radical displacement of the formation, or which may reduce the yield of the well, will not be permitted. Excavated material shall be disposed of as directed.
  1. Reverse Circulation Method: If the reverse circulation method is used for drilling wells, all of the drilling fluid shall be removed from the filter pack and the natural pervious formation. If in the opinion of the Owner the walls of the hole above the top of the filter pack require support during development operations, a temporary casing similar to that specified in paragraph TEMPORARY CASING shall be placed so as to extend from the ground surface to at least **3 ft (1 m)** below the top of the filter pack. The diameter of the hole shall be such as will permit the placement of the minimum thickness of filter pack as specified in paragraph FILTER PACK PLACEMENT. The drilling fluid shall be a suspension of fine grained soil or shall be a commercial product of a recognized manufacturer, shall be approved by the Owner, and shall have the characteristic of being readily removable from the filter pack and the walls of the formation by development as specified in paragraph DEVELOPMENT. The use of bentonite will not be permitted.
  2. Temporary Casing: Temporary well casing of either iron or steel of sufficient length to case to the bottom of all borings shall be available at the construction site. the Owner will direct the use of a temporary casing to the bottom of the boring during drilling and placement of screen, riser, and

filter pack when it believes it is necessary to provide adequate support to the sides of the hole. When the walls of the boring will require support only during development operations a temporary casing will be required to extend only to a depth **3 ft (3 m)** below the top of the filter pack. The temporary casing, shall have sufficient thickness to retain its shape and maintain a true section throughout its depth, and may be in sections of any convenient length. The temporary casing shall be such as to permit its removal without disturbing the filter pack, riser, or well screen. The setting of temporary casing shall be such that no cavity will be created outside of it at any point along its length. In the event the temporary casing should become unduly distorted or bent it shall be discarded and a new casing shall be used during installation of any additional relief wells.

**B. Installation Of Riser Pipe And Screen**

1. **Assembly:** All riser pipe and screen shall be in good condition before installation and all couplings and other accessory parts shall be securely fastened in place. The successive lengths of pipe shall be arranged to provide accurate placement of the screen sections in the bore hole. The riser-pipe shall be provided with an approved cap and a flanged top section, the top of which shall be set at the elevation directed. Centralizers shall be attached to the assembled riser pipe and screen in such numbers and of a type that they will satisfactorily center the riser pipe and screen in the well and will hold it securely in position while the filter pack material is being placed.
2. **Joints:** Sections of relief well pipe shall be joined together as specified in paragraph **COUPLINGS**. Joints shall be designed and constructed to have the strength of the pipe and where possible a strength capable to support the weight of the relief well stem as it is lowered into the hole. When not practicable to construct joints that will support the weight of the relief well stem, the stem shall be supported at the lower end by any approved means that will assure that the joints do not open while being lowered into place in the well.
3. **Installation:** The assembled riser pipe and screen shall be placed in the bore hole in such manner as to avoid jarring impacts and to ensure that the assembly is centered and not damaged or disconnected. The screen shall be suspended in the hole and not resting on the bottom of the hole. After the screen and riser pipe have been placed, a filter pack shall be constructed around the screen section as specified in paragraph **FILTER PACK PLACEMENT** and the well developed as specified in paragraph **DEVELOPMENT**. The top of the riser pipe shall be held at the designated elevation during placement of the filter pack.
4. **Check for Plumbness and Alignment:** The well shall be constructed and all casing set round, plumb, and true. The Contractor shall perform the following tests after the installation of the well but prior to backfilling, and before its acceptance. Additional tests may be made during the performance of the work at the option of the Contractor. Should the Contractor fail to correct, at no additional cost to the Owner, any faulty alignment or plumbness disclosed as a result of these tests, the Owner may refuse to accept the well. the Owner may waive the requirements for plumbness if in its judgement the Contractor has exercised all possible care in constructing the well and the defect is due to circumstances beyond its control or if the utility of the completed well is not materially affected or if the cost of necessary remedial measures will be excessive. In no event will the provisions with respect to alignment be waived.
  - a. **Plumbness:** Plumbness shall be tested by use of a plumb line. The plummet shall be suspended from a small diameter wire rope and its point of suspension shall be in the exact center of the plummet. The plummet shall be sufficiently heavy to stretch the wire rope taut. The wire rope shall pass over a guide sheave which shall be positioned above the top of the well and adjusted horizontally so that the plummet hangs in the center of the well. Displacement of the wire rope during the plumbness check shall be measured by means of a transparent plastic sheet on which a number of concentric circles shall be scribed or drawn, and which is centered on the top of the well. The exact center of these circles shall be marked, and then a slot, slightly larger than the plumb line and extending from this center to the edge, shall be cut in the plastic sheet. As the plummet is lowered, any out-of-plumb condition of the well will be indicated by the wire rope tending to drift away from the center, and the plastic sheet shall be rotated until the slot is oriented in the direction of this drift, while at all times maintaining the center of the concentric circles coincident with the center of the well. Measurement of the amount of drift shall be made

along the edge of the slot for each increment by which the plummet is lowered into the well. Drift at any depth shall be determined by multiplying the measured plumb line displacement by the total length of the plumb line and dividing the result by the fixed distance between the guide sheave and the top of the well. If desired, alignment may be calculated from the plumbness data in lieu of the alignment check described in paragraph ALIGNMENT. Should the well vary from the vertical in excess of allowable, the plumbness of the well shall be corrected by the Contractor at no additional cost to the Owner.

- b. Alignment: Alignment shall be tested by lowering into the well a section of cylinder or a dummy of the same length. The outside diameter of cylinder shall be smaller than the inside diameter of the well. Should the cylinder fail to move freely throughout the length of the well, the alignment of the well shall be corrected by the Contractor at no additional expense to the Owner.

- C. Filter Pack Placement: After the well screen and riser pipe have been installed, the filter pack material shall be placed by tremie, when using a well graded material, in an approved manner such that segregation will not occur. When using a uniform graded filter material, the material may be poured around the well screen at a rate that will prevent bridging of the material. The material shall be placed around all sides of the screen to assure that the screen is not pushed against the side of the bore hole causing the screen to come in contact with foundation material or prevent the proper thickness of filter from being placed uniformly around the screen. The filter pack shall be placed at a constant rate from the start of placement until it has reached the elevation directed. If a tremie is required, a double string of tremie pipe shall be used. The pipes shall be placed on opposite sides of the screen and/or casing, that is, 180 degrees apart, and shall be guided in such a manner that they will remain in this position throughout the placing process. The tremie pipes shall be set in place, filled completely with filter pack prior to being lifted off the bottom of the hole. The filter pack in the tremie pipe shall be kept above the water surface in the well throughout the placing process. In no case shall the gradation of the filter pack fall outside of the range specified in paragraph FILTER PACK.

D. Development

1. General: Following placement of filter pack materials, the Contractor shall develop the relief well by jetting, surging, intermittent pumping, or other approved methods as may be necessary to give the maximum yield of water. At the time of development of any relief well, the well shall be free of drawdown or surcharge effects due to pump testing, developing or drilling at another location. The Contractor shall be responsible for maintaining at the relief well the needed access and work area and clearance in the relief well necessary to accomplish development. The Contractor shall furnish, install, or construct the necessary discharge line and troughs to conduct and dispose of the discharge a sufficient distance from the work areas to prevent damage. Development shall be conducted to achieve a stable well of maximum efficiency and shall be continued until a satisfactory sand test, as specified in paragraph SAND TEST, is obtained. As development proceeds, filter pack material shall be added to the annular space around the screen to maintain the top elevation of the filter pack to the specified elevation. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well under all conditions. If at any time during the development process it becomes apparent in the opinion of the Owner that the well may be damaged, development operations shall be immediately terminated. the Owner may require a change in method if the method selected does not accomplish the desired results. the Owner may order that wells which continue to produce excessive amounts of fines after development for 6 hours be abandoned, plugged, and backfilled, and may require the Contractor to construct new wells nearby. All materials pulled into the well by the development process shall be removed prior to performing the pumping test.

- a. Jetting: Jetting should be performed using either a single or double ring jet. The jetting tool shall be constructed of high-strength material and conservatively designed and proportioned so that it will withstand high pressures. The jetting tool shall have two hydraulically balanced nozzles spaced 180 degrees **OR** four diameter holes spaced 90 degrees, **as directed**, apart and which shall exert the jetting force horizontally through the screen slots. The rings shall be constructed such that the tips of the jets shall be within **1/2 in. (13 mm)** from the inner surface of the well screen. The pump used in conjunction with

the jetting tool shall be capable of providing a minimum jetting fluid exit velocity of **150 feet per second (45 meters per second)**. Prior to commencing jetting, and following each jetting cycle, all sand and/or other materials shall be removed from inside the screen. All wells shall be pumped during the jetting cycle to remove incoming sand and other material. Such pumping shall be at a rate not less than 115 percent of the rate at which fluid is introduced through the jetting tool. This will allow a flow of material into the well as it is being developed. Water used for development shall be free of sand. the Owner may require other means of developing the well such as intermittent pumping method, variation of the intermittent pumping method, or surge block if it appears that the development of the well is not producing the desired results.

- b. Intermittent Pumping: Intermittent pumping shall be performed by pumping the well at a capacity sufficient to produce a rapid drawdown, stopping the pump (backflow through pump will not be permitted) to permit the water surface to rise to its former elevation, and repeating this procedure. Cycle time for this procedure will vary as directed but will not be more than 3 cycles per minute. A deep well turbine pump, or electric submersible pump with check valve, shall be used with any attachment necessary to accomplish rapid starting and stopping for intermittent pumping. The intake shall be set below the maximum expected drawdown in the well. Prior to commencing intermittent pumping, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. The amount of drawdown may be decreased if, in the opinion of the Owner, the efficiency of the well might otherwise be impaired.
  - c. Surging: Surging of the well shall require use of a circular block which is smaller in diameter than the inside diameter of the relief well and is constructed of a material which will not damage the screen if the block comes in contact with the screen, and a bailer or pump to remove materials drawn into the well. The surging shall be continued for a period of approximately one hour or until little or no additional material from the foundation or filter pack can be pulled through the screen. The surge block shall be moved by a steady motion up and down the full length of the well screen. Prior to commencing surging, and periodically during development by this method, all sand and/or other materials shall be removed from inside the screen. All materials pulled into the well by the surging process shall be removed by the Contractor.
- E. Backfilling: After the well has been developed, additional filter pack shall be added if necessary to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the annular space above the filter pack, shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with grout or concrete. The concrete backfill shall be placed to a depth at least equal to the existing impervious blanket. For PVC riser pipe, after the well has been developed, additional filter pack shall be added if necessary for it to meet the requirements of paragraph FILTER PACK PLACEMENT. Then the remaining annular space above the filter pack shall be backfilled by first placing a layer of concrete sand on the filter pack and then filling the remainder of the space up to the finished ground surface **OR** well pit, **as directed**, with bentonite. The temporary casing, if used, shall be withdrawn in increments as the backfill is placed. The Contractor shall fill with impervious material to original grade all pits such as those incidental to the reverse rotary circulation method of drilling.
- F. Plugging Of Abandoned Wells: The Contractor has the option of attempting to remove the well screen. If the well screen can be removed, the Contractor will grout the bore hole starting from the bottom of the hole. The grouting shall start at the elevation of the bottom of the tailpipe of the well. If the well screen can not be removed or breaks off during the removal attempt, the Contractor shall still be responsible for grouting the well from the bottom of the tailpipe to within **3 ft (1 m)** of ground surface. Either of the above abandonment procedures may require the Contractor to redrill the hole so that the bore hole can be grouted. The well shall be grouted from the bottom of the tailpipe. After the grout has setup the riser pipe shall be cutoff. Then the hole shall be backfilled. The cement grout mixture proportion to be used shall be submitted for approval.



G. Tests

1. Pump Test: Upon completion but before acceptance, each well shall be subjected to a pump test of which a sand test will form a part. The Contractor shall provide a deep well turbine pump, capable of producing the specified drawdowns over periods of time sufficient to satisfactorily perform the pump test specified herein. The intake shall be set below the maximum expected drawdown in the well. The amount of sand shall be measured after each test. The pump shall be complete with either gasoline, diesel, or electric motor of adequate size. In case an electric motor is used, the Contractor shall provide, without additional cost to the Owner, the electric power and the necessary wiring. The Contractor shall provide an open tube or other approved means for accurately determining the water level in the well. The Contractor shall furnish and install an orifice meter of approved design or other approved equipment for the purpose of measuring the discharge from the well during the pumping test. The Contractor shall furnish, install, or construct the necessary pipe discharge line, troughs, or ditches necessary to dispose of the pumping test discharge a sufficient distance from the work area to prevent damage. The tests will be conducted under the direction of the Owner and may be made as soon as each well is completed. Test data will be recorded by the Owner. The Contractor shall test each well by pumping continuously for a minimum of 6 hours. Prior to starting the pump test all material shall be removed from the bottom of the well. If the test is interrupted, other than by order of the Owner, prior to the completion of the specified period of continuous operation, the test shall be re-run. In addition to the required pumping test, the Owner may direct the Contractor to perform additional pump tests. Such additional testing shall conform in general to the requirements specified herein except that the duration of the tests and the approximate draw-down will be determined by the Owner. In the event that sand or other material collects in the well as a result of the pump test, accurate measurements shall be taken as to the quantity of material in the well and all such material shall be removed by the Contractor. Upon completion of the pump test, the Contractor shall remove all equipment, discharge lines, electrical lines, lumber, and debris, and shall backfill any excavated areas with impervious material.
2. Sand Test: As part of each Pump Test or at the end of each intermittent pumping a determination of the amount of sand (filter pack and/or foundation material) a well is producing shall be performed. Prior to starting the sand test all material shall be removed from the bottom of the tailpipe. After the pump is at the desired pumping rate the flow from the discharge shall be diverted into a container that will collect all the sand being carried by the water **OR** through a Rossum Sand Tester, **as directed**. Upon completion of the test the amount of sand in the tailpipe shall be determined to verify that no material is being deposited in the bottom of the well.
3. Filter Pack Sampling and Testing: The Contractor shall verify that all materials conform to the specifications before delivery to the project. The particle size distribution of the filter pack shall be sampled and tested by the Contractor in accordance with ASTM C 136 and ASTM D 75. Within 48 hours before being placed in the relief well to be back-filled, the filter pack shall be sampled from the material stockpiled at the project site. There shall be at least one particle size distribution test on the filter pack for each well. A pump test shall be performed in accordance with technical provisions herein specified.
4. Reports: Reports shall include, for each relief well, logs of the boring, elevations of the well screen, top of riser pipe, bottom of the tailpipe, filter pack gradation, quantity of filter pack added during development, pump test, sand test, and report of backfilling. The log of backfill material shall include the filter pack particle size distribution test data, and notes concerning installation and development of the relief well. The pump test log shall include the duration of the test and the draw-down response data with time in the pumped well, in adjacent wells, and in nearby piezometers. The relief well log and the pump test log shall be submitted to the Owner. The Contractor shall also submit a report of the well installation to the appropriate public agency and in the form required by state statutory and/or regulatory requirements specified in paragraph REGULATORY REQUIREMENTS.

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## SECTION 31 62 16 16 - STEEL H PILES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for steel H piles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes steel H piles.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For steel piles. Show fabrication and installation details for piles, including details of driving points, splices, and pile caps.
  - a. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
  - b. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Mill Test Reports: For steel H piles, steel castings, and steel plate, signed by manufacturer.
5. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
6. Static Pile Test Reports: Submit within three days of completing each test.
7. Pile-Driving Records: Submit within three days of driving each pile.
8. Field quality-control reports.
9. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

#### D. Quality Assurance

1. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
2. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
3. Preinstallation Conference: Conduct conference at Project site.

#### E. Delivery, Storage, And Handling

1. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent buckling or physical damage.
  - a. Painted Piles: Protect finish and touch up paint damage before driving piles.

#### F. Project Conditions

1. Protect structures, underground utilities, and other construction from damage caused by pile driving.
2. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Provide photographs **OR** video, **as directed**, of conditions that might be misconstrued as damage caused by pile driving.

### 1.2 PRODUCTS

#### A. Steel H Piles



1. High-Strength, Low-Alloy, Columbium-Vanadium Structural Steel: ASTM A 572/A 572M, **Grade 50 (Grade 345) OR Grade 60 (Grade 415), as directed.**
2. High-Strength, Low-Alloy, Nickel, Copper, Phosphorous Steel H Piles: ASTM A 690/A 690M.
3. High-Strength, Low-Alloy, Structural Steel: ASTM A 588/A 588M.

**B. Pile Accessories**

1. Driving Points: Manufacturer's standard one-piece driving point, fabricated from steel castings as follows to provide full bearing of web and flange of pile tip:
  - a. Carbon-Steel Castings: ASTM A 27/A 27M, **Grade 65-35 (Grade 450-240), heat treated OR Grade N1, as directed.**
  - b. High-Strength Steel Castings: ASTM A 148/A 148M, **Grade 80-40 (Grade 550-275) OR Grade 90-60 (Grade 620-415), as directed.**
2. Splice Unit: Manufacturer's standard splice unit, fabricated from two connected steel plates, of same material as H pile or material of equal strength, shaped to encase web and part of each flange.

**C. Paint**

1. Paint, **as directed**: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, black **OR** red **OR** manufacturer's standard color, **as directed**.

**D. Fabrication**

1. Fabricate and assemble piles in shop to greatest extent possible.
2. Pile-Length Markings: Mark each pile with horizontal lines at **12-inch (305-mm)** intervals; label the distance from pile tip at **60-inch (1.52-m)** intervals. Maintain markings on piles until driven.
3. Fabricate full-length piles to eliminate splicing during driving, with ends square.  
**OR**  
Fabricate full-length piles by splicing lengths of H pile together. Accurately mill meeting ends of piles and bevel for welding. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.
4. Splice Units: Notch web of pile, fit splice unit into position, and weld according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.  
**OR**  
Continuously Welded Splices: Splice piles by continuously welding according to AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
  - a. Splice piles during fabrication or field installation, **as directed**.
5. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.

**E. Shop Painting, as directed**

1. General: Shop paint steel pile surfaces, except for surfaces to be encased in concrete, as follows:
  - a. Extend painting to a depth of **60 inches (1.52 m)** below finished grade **OR** low-tide level, **as directed**, to top of exposed pile.
2. Surface Preparation: Clean surfaces to be painted. Remove loose rust and loose mill scale, spatter, slag, and flux deposits. Prepare surfaces according to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
3. Painting: Immediately after surface preparation, apply coat of paint according to manufacturer's written instructions to provide a dry film thickness of not less than **8 mils (0.2 mm)**.
  - a. Apply second coat to provide a dry film thickness of not less than **8 mils (0.2 mm)**, resulting in a two-coat paint system thickness of not less than **16 mils (0.4 mm)**.

- b. Apply second and third coats with each coat having a dry film thickness of not less than **8 mils (0.2 mm)**, resulting in a three-coat paint system thickness of not less than **24 mils (0.6 mm)**.
- c. Mark pile lengths after shop painting.

### 1.3 EXECUTION

#### A. Examination

1. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of **6 to 12 inches (152 to 305 mm)** above bottom of footing or pile cap.

#### B. Driving Equipment

1. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
2. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
3. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that will hold full length of pile firmly in position and in axial alignment with hammer.

#### C. Static Pile Tests, **as directed**

1. General: Static pile tests will be used to verify driving criteria and pile lengths and to confirm allowable load of piles.
  - a. Furnish test piles **60 inches (1.52 m)** longer than production piles.
  - b. Determination of actual length of piles will be based on results of static pile tests.
2. Pile Tests: Arrange and perform the following pile tests:
  - a. Axial Compressive Static Load Test: ASTM D 1143.
  - b. Axial Tension Static Load Test: ASTM D 3689.
  - c. Lateral Load Test: ASTM D 3966.
3. Equip each test pile with two telltale rods, according to ASTM D 1143, for measuring deformation during load test.
4. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify the Owner at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
  - a. Allow a minimum of seven days to elapse after driving test piles before starting pile testing.
  - b. Number of Test Piles: One pile **OR** As indicated, **as directed**.
5. Driving Test Piles: Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
6. Approval Criteria: Allowable load shall be the load acting on the test pile when the lesser of, **as directed**, the following criteria are met, divided by a factor of safety of 2:
  - a. Net settlement, after deducting rebound, of not more than **0.01 inch/ton (0.25 mm/907 kg)** of test load.
  - b. Total settlement exceeds the pile elastic compression by **0.15 inch (4 mm)**, plus 1.0 percent of the tip diagonal dimension.
  - c. A plunging failure or sharp break in the load settlement curve.
7. Test Pile-Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified professional engineer, **as directed**. Include same data as required for driving records of permanent piles.
8. Test piles that comply with requirements, including location tolerances, may be used on Project.

#### D. Driving Piles

1. General: Continuously drive piles to elevations or penetration resistance indicated or established by static load testing of piles, **as directed**. Establish and maintain axial alignment of leads and piles before and during driving.
2. Predrilling, **as directed**: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
  - a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
3. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
4. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
  - a. Location: **4 inches (102 mm)** from location indicated after initial driving, and **6 inches (152 mm)** after pile driving is completed.
  - b. Plumb: Maintain **1 inch (25 mm)** in **4 feet (1.2 m)** from vertical, or a maximum of **4 inches (102 mm)**, measured when pile is aboveground in leads.
  - c. Batter Angle: Maximum **1 inch (25 mm)** in **4 feet (1.2 m)** from required angle, measured when pile is aboveground in leads.
5. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.
  - a. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding **72 inches (1.83 m)**.

**OR**

Fill holes left by withdrawn piles as directed by the Owner.

**OR**

Abandon and cut off rejected piles as directed by the Owner. Leave rejected piles in place and install new piles in locations as directed by the Owner.
6. Cutting Off: Cut off tops of driven piles square with pile axis and at elevations indicated.
7. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer, **as directed**. Include the following data:
  - a. Project name and number.
  - b. Name of Contractor.
  - c. Pile location in pile group and designation of pile group.
  - d. Sequence of driving in pile group.
  - e. Pile dimensions.
  - f. Ground elevation.
  - g. Elevation of tips after driving.
  - h. Final tip and cutoff elevations of piles after driving pile group.
  - i. Records of redriving.
  - j. Elevation of splices.
  - k. Type, make, model, and rated energy of hammer.
  - l. Weight and stroke of hammer.
  - m. Type of pile-driving cap used.
  - n. Cushion material and thickness.
  - o. Actual stroke and blow rate of hammer.
  - p. Pile-driving start and finish times, and total driving time.
  - q. Time, pile-tip elevation, and reason for interruptions.
  - r. Number of blows for every **12 inches (305 mm)** of penetration, and number of blows per **1 inch (25 mm)** for the last **6 inches (152 mm)** of driving.
  - s. Pile deviations from location and plumb.
  - t. Preboring, jetting, or special procedures used.
  - u. Unusual occurrences during pile driving.

#### E. Field Quality Control

1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
    - a. Pile foundations.
  2. Testing Agency: Engage a qualified independent testing agency to perform tests and inspections.
  3. Tests and Inspections:
    - a. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D 4945 during initial driving and during restriking on five single piles **OR** 3 percent of piles, **as directed**.
    - b. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1/D1.1M and inspection procedures listed below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate do not comply with the Contract Documents.
      - 1) Liquid Penetrant Inspection: ASTM E 165.
      - 2) Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
      - 3) Radiographic Inspection: ASTM E 94, minimum quality level "2-2T."
      - 4) Ultrasonic Inspection: ASTM E 164.
- F. Touchup Painting, **as directed**
1. Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC-PA 1. Use same paint and apply same number of coats as specified for shop painting.
    - a. Apply touchup paint before driving piles to surfaces that will be immersed or inaccessible after driving.
- G. Disposal
1. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

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## SECTION 31 62 16 19 - CONCRETE-FILLED STEEL PILES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for concrete-filled steel piles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes concrete-filled steel shell and pipe piles.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For composite piles. Show fabrication and installation details for piles, including splices and tip details.
  - a. Indicate welds by standard AWS symbols, distinguishing between shop and field welds, and show size, length, and type of each weld.
  - b. Indicate locations, sizes, type, and arrangement of reinforcement.
  - c. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Welding certificates.
4. Design Mixes: For each concrete mix. Include revised mix proportions when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
5. Material Certificates: For steel shell piles and accessories, steel pipe piles and accessories, steel reinforcement and concrete admixtures, from manufacturer.
6. Material Test Reports: For concrete materials.
7. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
  - a. Include mandrel type and details.
8. Static Pile Test Reports: Submit within three days of completing each test.
9. Pile-Driving Records: Submit within three days of driving each pile.
10. Field quality-control reports.
11. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

#### D. Quality Assurance

1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
2. Comply with requirements in ACI 301, "Specifications for Structural Concrete."
3. Welding Qualifications: Qualify procedures and personnel according to the following:
  - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel"
  - b. AWS D1.3, "Structural Welding Code - Sheet Steel."
4. Preinstallation Conference: Conduct conference at Project site.

#### E. Delivery, Storage, And Handling

1. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent physical damage.
  - a. Painted Piles: Protect finish and touch up damage before driving piles.

#### F. Project Conditions

1. Protect structures, underground utilities, and other construction from damage caused by pile driving.
2. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Provide photographs **OR** video, **as directed**, of conditions that might be misconstrued as damage caused by pile driving.

## 1.2 PRODUCTS

### A. Steel Shell Piles

1. Fluted Pile Shells: Manufacturer's standard, vertically fluted pile shells; cold formed from steel sheet; **50,000-psi (345-MPa)** minimum yield strength after forming. Fabricate watertight, uniformly tapered sections with forged-steel conical nose welded to tip.
  - a. Constant Diameter Extensions: Fabricate with splice overlap capable of telescoping into tapered section.
  - b. Taper: **0.14 inch in 12 inches (1:86) OR 0.25 inch in 12 inches (1:48) OR 0.40 inch in 12 inches (1:30), as directed.**
  - c. Thickness: **0.150 inch (3.80 mm) OR 0.179 inch (4.55 mm) OR 0.209 inch (5.31 mm) OR 0.239 inch (6.07 mm), as directed.**
2. Helically Corrugated Pile Shells: Manufacturer's standard, helically corrugated, uniform-diameter, steel sheet shell piles; of sufficient strength and thickness to remain watertight and resist distortion and buckling due to soil pressure, internal mandrel operation, or redriving. Fabricate in one-piece lengths with **3/16-inch- (4.76-mm-)** thick, minimum steel-plate boot continuously welded to tip and as follows:
  - a. Nominal Diameter: **8-5/8 inches (219 mm) OR 10-5/8 inches (270 mm) OR 11-1/8 inches (283 mm) OR 12-1/4 inches (311 mm) OR 14 inches (350 mm) OR 16-1/8 inches (410 mm), as directed.**
  - b. Thickness: **0.048 inch (1.21 mm), minimum OR 0.060 inch (1.52 mm), minimum OR 0.075 inch (1.90 mm), minimum OR 0.105 inch (2.66 mm), as directed.**

### B. Steel Pipe Piles

1. Steel Pipe: ASTM A 252, Grade 2 **OR** Grade 3, **as directed**; seamless or welded.

### C. Steel Reinforcement

1. Reinforcing Bars: ASTM A 615/A 615M, **Grade 60 (Grade 420)**; deformed.
2. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M.
3. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending, as follows:
  - a. Steel Reinforcement: ASTM A 615/A 615M, **Grade 60 (Grade 420) OR ASTM A 706/A 706M, as directed**; deformed.
4. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M, as follows:
  - a. Steel Reinforcement: ASTM A 615/A 615M, **Grade 60 (Grade 420) OR ASTM A 706/A 706M, as directed**; deformed.
5. Plain Steel Wire: ASTM A 82/A 82M, as drawn **OR** galvanized, **as directed**.
6. Deformed-Steel Wire: ASTM A 496/A 496M.
7. Epoxy-Coated-Steel Wire: ASTM A 884/A 884M, Class A coated, plain **OR** deformed, **as directed**.

### D. Concrete Materials

1. Portland Cement: ASTM C 150, Type I or II.
  - a. Fly Ash: ASTM C 618, Class C or F.
  - b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
2. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag **OR** Type IP, portland-pozzolan **OR** Type I (PM), pozzolan-modified portland **OR** Type I (SM), slag-modified Portland, **as directed**, cement.



3. Normal-Weight Aggregates: ASTM C 33, Class 4S **OR** Class 4M **OR** Class 1N, **as directed**, uniformly graded, **3/4-inch (19-mm)** maximum aggregate size. Provide aggregates from a single source.
  4. Water: Potable, complying with ASTM C 94/C 94M requirements.
  5. Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent chloride ions by mass of cementitious material.
    - a. Air-Entraining Admixture: ASTM C 260.
    - b. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
    - c. Retarding Admixture: ASTM C 494/C 494M, Type B.
    - d. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
    - e. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
    - f. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
    - g. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
- E. Pile Accessories
1. Driving Points: Manufacturer's standard 60-degree conical driving point, with integral reinforcing ribs, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
  2. Inside Cutting Shoes: Manufacturer's standard, inside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
  3. Outside Cutting Shoes: Manufacturer's standard, outside-flanged, open-ended cutting shoe, to provide full bearing of pipe pile tip. Fabricate from steel castings as follows:
    - a. Carbon-Steel Castings: ASTM A 27/A 27M, **Grade 65-35 (Grade 450-240)**, heat treated **OR** Grade N1, **as directed**.
    - b. High-Strength Steel Castings: ASTM A 148/A 148M, **Grade 80-40 (Grade 550-275) OR Grade 90-60 (Grade 620-415)**, **as directed**.
  4. Splice Coupling: Manufacturer's standard splice coupling, rolled from ASTM A 36/A 36M, carbon-steel bar or cast from heat-treated carbon steel, ASTM A 27/A 27M, **Grade 65-35 (Grade 450-240)**, with interior stop and internally tapered for friction fit driving.
- F. Paint
1. Paint: SSPC-Paint 16; self-priming, two-component, coal-tar epoxy polyamide, black **OR** red **OR** manufacturer's standard color, **as directed**.
- G. Concrete Mixes
1. Prepare concrete design mixes according to ACI 301, determined by either laboratory trial batch or field test data basis.
    - a. Use a qualified testing agency for preparing and reporting proposed mix designs determined by laboratory trial batch.
  2. Proportion mixes according to ACI 301 to provide normal-weight concrete suitable for piles with the following properties:
    - a. Compressive Strength (28 Days): **5000 psi (34.5 MPa) OR 4000 psi (27.6 MPa) OR 3000 psi (20.7 MPa)**, **as directed**.
    - b. Maximum Water-Cementitious Material Ratio at Point of Placement: 0.45 **OR** 0.50, **as directed**.
    - c. Slump Limit: **5 inches (127 mm) OR 8 inches (203 mm)**, **as directed**, plus or minus **1 inch (25 mm)**.
  3. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content of 6.0 percent, plus or minus 1.5 **OR** 2.5 to 4.5, **as directed**, percent.
  4. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.
  5. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 **OR** 0.30, **as directed**, percent by weight of cement.
  6. Concrete-mix design adjustments may be considered if characteristics of materials, Project conditions, weather, test results, or other circumstances warrant. Resubmit and obtain approval from the Owner of proposed changes to concrete-mix proportions.



## H. Fabrication

1. Fabricate and assemble piles in shop to greatest extent possible.
2. Fabricate full-length piles to eliminate splicing during driving.

**OR**

Fabricate full-length piles by splicing pile lengths together. Maintain axial alignment of pile lengths. Maintain structural properties of pile across splice.

- a. Splice Coupling: Fit splice coupling into position and weld to adjoining steel pipe pile sections according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
  - b. Welded Splices: Accurately mill meeting ends of steel pipe piles and bevel for welding. Continuously weld pile according to AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.
  - c. Welded Splices: Continuously weld steel shell pile according to manufacturer's written instructions and AWS D1.1/D1.1M and AWS D1.3, **as directed**, for procedures, appearance and quality of welds, and methods used in correcting welding work.
  - d. Splice piles during fabrication or field installation.
3. Fit and weld driving points to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.

**OR**

Fit and weld cutting shoes to tip of pile according to manufacturer's written instructions and AWS D1.1/D1.1M for procedures, appearance and quality of welds, and methods used in correcting welding work.

4. Pile-Length Markings: Mark each pile with horizontal lines at **12-inch (305-mm)** intervals; label the distance from pile tip at **60-inch (1.52-m)** intervals. Maintain markings on piles until driven.

I. Shop Painting, **as directed**

1. General: Shop paint steel pile surfaces, except for surfaces to be encased in concrete, as follows:
  - a. Extend painting to a depth of **60 inches (1.52 m)** below finished grade **OR** low-tide level, **as directed**, to top of exposed pile.
2. Surface Preparation: Clean surfaces to be painted. Remove loose rust and loose mill scale, and remove spatter, slag, or flux deposits. Prepare surfaces according to SSPC-SP 10/NACE No. 2, "Near-White Blast Cleaning."
3. Painting: Immediately after surface preparation, apply coat of paint according to manufacturer's written instructions to provide a dry film thickness of not less than **8 mils (0.2 mm)**.
  - a. Apply second coat to provide a dry film thickness of not less than **8 mils (0.2 mm)**, resulting in a two-coat paint system thickness of not less than **16 mils (0.4 mm)**.
  - b. Apply second and third coats with each coat having a dry film thickness of not less than **8 mils (0.2 mm)**, resulting in a three-coat paint system thickness of not less than **24 mils (0.6 mm)**.
  - c. Mark pile lengths after shop painting.

## J. Concrete Mixing

1. Ready-Mixed Concrete: Comply with ASTM C 94/C 94M.
  - a. Do not add water to concrete mix after mixing.
  - b. Maintain concrete temperature to not exceed **90 deg F (32 deg C)**.

## 1.3 EXECUTION

## A. Examination

1. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of **6 to 12 inches (152 to 305 mm)** above bottom of footing or pile cap.
- B. Driving Equipment
1. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
  2. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
  3. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that will hold full length of pile firmly in position and in axial alignment with hammer.
  4. Mandrel: Expandable mandrel, capable of distributing driving energy throughout length of steel shell pile.
- C. Static Pile Tests, **as directed**
1. General: Static pile tests will be used to verify driving criteria and pile lengths and to confirm allowable load of piles.
    - a. Furnish test piles **60 inches (1.52 m)** longer than production piles.
    - b. Determination of actual length of piles will be based on results of static pile tests.
  2. Pile Tests: Arrange and perform the following pile tests:
    - a. Axial Compressive Static Load Test: ASTM D 1143.
    - b. Axial Tension Static Load Test: ASTM D 3689.
    - c. Lateral Load Test: ASTM D 3966.
  3. Equip each test pile with two telltale rods, according to ASTM D 1143, for measuring deformation during load test.
  4. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify the Owner at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
    - a. Allow a minimum of seven days to elapse after driving test piles before starting pile testing.
    - b. Number of Test Piles: One pile **OR** As indicated, **as directed**.
  5. Driving Test Piles: Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
    - a. Pile Design Load: As indicated **OR as directed**.
  6. Approval Criteria: Allowable load shall be the load acting on the test pile when the lesser of, **as directed**, the following criteria are met, divided by a factor of safety of 2:
    - a. Net settlement, after deducting rebound, of not more than **0.01 inch/ton (0.25 mm/907 kg)** of test load.
    - b. Total settlement exceeds the pile elastic compression by **0.15 inch (4 mm)**, plus 1.0 percent of the tip diagonal dimension.
    - c. A plunging failure or sharp break in the load settlement curve.
  7. Test Pile-Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified professional engineer, **as directed**. Include same data as required for driving records of permanent piles.
  8. Test piles that comply with requirements, including location tolerances, may be used on Project.
- D. Steel Reinforcement
1. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
  2. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
  3. Fabricate and install reinforcement cages symmetrically about axis of pile shell **OR** pipe, **as directed**, in a single unit.

4. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover on reinforcement.
5. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.

E. Concrete Placement

1. Do not place concrete until other piles within a radius of **20 feet (6 m)** have been driven and approved.
2. Inspection: Before placing concrete, allow testing and inspecting agency to visually inspect and verify that each pile shell **OR** pipe, **as directed**, is clean, watertight, plumb, and free of distortion or other defects.
3. Place concrete in a continuous operation and without segregation immediately after cleaning out pile shell **OR** pipe, **as directed**.
4. Place concrete by means of bottom discharge bucket, flexible drop chute, steep-sided funnel hopper, or tremie or pump concrete into place.
5. Place concrete in a dry pile shell **OR** pipe, **as directed**, unless placement underwater is approved by the Owner.
  - a. Place concrete underwater by tremie method or pumping. Control placement operations to ensure tremie is embedded no less than **60 inches (1.52 m)** into concrete, and flow of tremied concrete is continuous from bottom to top of pile shell **OR** pipe, **as directed**.
  - b. Other methods of depositing concrete may be used if approved by the Owner.
6. Consolidate final **10 feet (3 m)** of concrete during placement to ensure that concrete is thoroughly worked around steel reinforcement and into corners.
7. Screed concrete level at cutoff elevation and apply a scoured, rough finish.

F. Driving Piles

1. General: Continuously drive piles to elevations or penetration resistance indicated or established by static load testing of piles, **as directed**. Establish and maintain axial alignment of leads and piles before and during driving.
2. Predrilling, **as directed**: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
  - a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
3. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
4. Pile Splices: Splice piles during installation and align pile segments concentrically.
5. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
  - a. Location: **4 inches (102 mm)** from location indicated after initial driving, and **6 inches (152 mm)** after pile driving is completed.
  - b. Plumb: Maintain **1 inch (25 mm)** in **4 feet (1.2 m)** from vertical, or a maximum of **4 inches (102 mm)**, measured when pile is aboveground in leads.
  - c. Batter Angle: Maximum **1 inch (25 mm)** in **4 feet (1.2 m)** from required angle, measured when pile is aboveground in leads.
6. Excavation: Clean out steel pipe pile by removing soil and debris from inside pile before placing steel reinforcement or concrete.
7. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.
  - a. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding **72 inches (1.83 m)**.

**OR**

Fill holes left by withdrawn piles as directed by the Owner.

**OR**

Abandon and cut off rejected piles as directed by the Owner. Leave rejected piles in place and install new piles in locations as directed by the Owner.

8. Cutting Off: Cut off tops of driven piles square with pile axis and at elevations indicated.
9. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer, **as directed**. Include the following data:
  - a. Project name and number.
  - b. Name of Contractor.
  - c. Pile location in pile group and designation of pile group.
  - d. Sequence of driving in pile group.
  - e. Pile dimensions.
  - f. Ground elevation.
  - g. Elevation of tips after driving.
  - h. Final tip and cutoff elevations of piles after driving pile group.
  - i. Records of redriving.
  - j. Elevation of splices.
  - k. Type, make, model, and rated energy of hammer.
  - l. Weight and stroke of hammer.
  - m. Type of pile-driving cap used.
  - n. Cushion material and thickness.
  - o. Actual stroke and blow rate of hammer.
  - p. Pile-driving start and finish times, and total driving time.
  - q. Time, pile-tip elevation, and reason for interruptions.
  - r. Number of blows for every **12 inches (305 mm)** of penetration, and number of blows per **1 inch (25 mm)** for the last **6 inches (152 mm)** of driving.
  - s. Pile deviations from location and plumb.
  - t. Preboring, jetting, or special procedures used.
  - u. Unusual occurrences during pile driving.

G. Field Quality Control

1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
  - a. Pile foundations.
2. Testing Agency: Engage a qualified independent testing agency to perform tests and inspections.
3. Tests and Inspections:
  - a. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D 4945 during initial driving and during restriking on 5 single piles **OR** 3 percent of piles, **as directed**.
  - b. Low-strain integrity measurement shall be performed and reported for each pile.
  - c. Weld Testing: In addition to visual inspection, welds shall be tested and inspected according to AWS D1.1/D1.1M and the inspection procedures listed in subparagraphs below, at testing agency's option. Correct deficiencies in Work that test reports and inspections indicate does not comply with the Contract Documents.
    - 1) Liquid Penetrant Inspection: ASTM E 165.
    - 2) Magnetic Particle Inspection: ASTM E 709; performed on root pass and on finished weld. Cracks or zones of incomplete fusion or penetration will not be accepted.
    - 3) Radiographic Inspection: ASTM E 94; minimum quality level "2-2T."
    - 4) Ultrasonic Inspection: ASTM E 164.
  - d. Concrete: Sampling and testing of concrete for quality control shall include the following:
    - 1) Sampling Fresh Concrete: ASTM C 172, except modified for slump to comply with ASTM C 94/C 94M.
      - a) Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test, but no fewer than one test for each concrete load.
      - b) Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is **40 deg F (5 deg C)** and below or when **80 deg F (27 deg C)** and above, and one test for each set of compressive-strength specimens.

- c) Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
- d) Compressive-Strength Tests: ASTM C 39/C 39M; one set for each truck load. One specimen shall be tested at seven days, two specimens shall be tested at 28 days, and one specimen shall be retained in reserve for later testing if required.
- 2) When frequency of testing will provide fewer than five strength tests for a given class of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
- 3) When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, evaluate current operations and provide corrective procedures for protecting and curing in-place concrete.
- 4) Strength level of concrete will be considered satisfactory if averages of sets of three consecutive strength test results equal or exceed specified compressive strength and no individual strength test result falls below specified compressive strength by more than 500 psi (3.45 MPa).
- 5) Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, concrete type and class, location of concrete batch in piles, design compressive strength at 28 days, concrete-mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- 6) Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted but shall not be used as sole basis for acceptance or rejection.
- 7) Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate concrete strengths or other requirements have not been met.

H. Touchup Painting, as directed

- 1. Clean field welds, splices, and abraded painted areas and field-apply paint according to SSPC-PA 1. Use same paint and apply same number of coats as specified for shop painting.
  - a. Apply touchup paint before driving piles to surfaces that will be immersed or inaccessible after driving.

I. Disposal

- 1. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

END OF SECTION 31 62 16 19

## SECTION 31 62 19 00 - TIMBER PILES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for timber piles. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes round timber piles.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For timber piles. Show fabrication and installation details for piles, including details of driving shoes, tips or boots, and pile butt protection.
  - a. Include arrangement of static pile reaction frame, test and anchor piles, equipment, and instrumentation. Submit structural analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
3. Round timber pile treatment data as follows, including chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material:
  - a. For each type of preservative-treated timber product include certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards.
  - b. For waterborne-treated products include statement that moisture content of treated materials was reduced to levels indicated before shipment to Project site.
4. Pile-Driving Equipment Data: Include type, make, and rated energy range; weight of striking part of hammer; weight of drive cap; and, type, size, and properties of hammer cushion.
5. Static Pile Test Reports: Submit within three days of completing each test.
6. Pile-Driving Records: Submit within three days of driving each pile.
7. Field quality-control reports.
8. Warranty of chemical treatment manufacturer for each type of treatment.
9. Preconstruction Photographs: Photographs or video of existing conditions of adjacent construction. Submit before the Work begins.

#### D. Quality Assurance

1. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
2. Preinstallation Conference: Conduct conference at Project site.

#### E. Delivery, Storage, And Handling

1. Deliver piles to Project site in such quantities and at such times to ensure continuity of installation. Handle and store piles at Project site to prevent breaks, cuts, abrasions, or other physical damage and as required by AWPA M4.
  - a. Do not drill holes or drive spikes or nails into pile below cutoff elevation.

#### F. Project Conditions

1. Protect structures, underground utilities, and other construction from damage caused by pile driving.
2. Preconstruction Photographs: Inventory and record the condition of adjacent structures, underground utilities, and other construction. Provide photographs **OR** video, **as directed**, of conditions that might be misconstrued as damage caused by pile driving.



## 1.2 PRODUCTS

### A. Timber Piles

1. Round Timber Piles: ASTM D 25, unused, clean peeled, one piece from butt to tip; of the following species and size basis:
  - a. Species: Coastal Douglas fir **OR** Southern yellow pine, **as directed**.
  - b. Size Basis: Butt circumference **OR** Class A **OR** Class B **OR** Tip circumference **OR** 8-inch (203-mm) tip and natural taper, **as directed**.
2. Pressure-treat round timber piles according to AWWA C3 and, **as directed**, AWWA C18 **OR** AWWA C14, **as directed**, as follows:
  - a. Service Condition: Land and freshwater **OR** Foundation **OR** Saltwater **OR** Marine piles - dual treatment, **as directed**.
  - b. Treatment: Waterborne preservative **OR** Creosote or creosote solution **OR** Oil-borne preservative **OR** Waterborne preservative, severe marine borer hazard **OR** Dual treatment consisting of waterborne preservative, followed by creosote or creosote solution, **as directed**.

### B. Pile Accessories

1. Driving Shoes: Fabricate from ASTM A 1011/A 1011M, hot-rolled carbon-steel strip to suit pile-tip diameter, of the following type and thickness, and secure to pile tip so as to not affect pile alignment during driving:
  - a. Type: Flat boot **OR** Arrow point, **as directed**.
  - b. Thickness: 3/16 inch (4.8 mm) **OR** 1/4 inch (6 mm), **as directed**.

### C. Fabrication

1. Pile Tips: Cut and shape pile tips to accept driving shoes. Fit and fasten driving shoes to pile tips according to manufacturer's written instructions.
2. Pile Butt: Trim pile butt and cut perpendicular to longitudinal axis of pile. Chamfer and shape butt to fit tightly to driving cap of hammer.
3. Field-Applied Wood Preservative: Treat field cuts, holes, and other penetrations according to AWWA M4.
  - a. Coal-tar roofing cement for treating drilled holes or sealing cutoffs shall be free of asbestos.
4. Pile Splices: Splices will not be permitted.
5. Pile-Length Markings: Mark each pile with horizontal lines at 12-inch (305-mm) intervals; label the distance from pile tip at 60-inch (1.52-m) intervals. Maintain markings on piles until driven.

## 1.3 EXECUTION

### A. Examination

1. Site Conditions: Do not start pile-driving operations until earthwork fills have been completed or excavations have reached an elevation of 6 to 12 inches (152 to 305 mm) above bottom of footing or pile cap.

### B. Driving Equipment

1. Pile Hammer: Air-, steam-, hydraulic-, or diesel-powered type capable of consistently delivering adequate peak-force duration and magnitude to develop the ultimate capacity required for type and size of pile driven and character of subsurface material anticipated.
2. Hammer Cushions and Driving Caps: Between hammer and top of pile, provide hammer cushion and steel driving cap as recommended by hammer manufacturer and as required to drive pile without damage.
3. Leads: Use fixed, semifixed, or hanging-type pile-driver leads that will hold full length of pile firmly in position and in axial alignment with hammer.

C. Static Pile Tests, **as directed**

1. General: Static pile tests will be used to verify driving criteria and pile lengths and to confirm allowable load of piles.
  - a. Furnish test piles **60 inches (1.52 m)** longer than production piles.
  - b. Determination of actual length of piles will be based on results of static pile tests.
2. Pile Tests: Arrange and perform the following pile tests:
  - a. Axial Compressive Static Load Test: ASTM D 1143.
  - b. Axial Tension Static Load Test: ASTM D 3689.
  - c. Lateral Load Test: ASTM D 3966.
3. Equip each test pile with two telltale rods, according to ASTM D 1143, for measuring deformation during load test.
4. Provide pile reaction frame, anchor piles, equipment, and instrumentation with sufficient reaction capacity to perform tests. Notify the Owner at least 48 hours in advance of performing tests. On completion of testing, remove testing structure, anchor piles, equipment, and instrumentation.
  - a. Allow a minimum of seven days to elapse after driving test piles before starting pile testing.
  - b. Number of Test Piles: One pile **OR** As indicated, **as directed**.
5. Driving Test Piles: Drive test piles at locations indicated to the minimum penetration or driving resistance indicated. Use test piles identical to those required for Project and drive with appropriate pile-driving equipment operating at rated driving energy to be used in driving permanent piles.
6. Approval Criteria: Allowable load shall be the load acting on the test pile when the lesser of, **as directed**, the following criteria are met, divided by a factor of safety of 2:
  - a. Net settlement, after deducting rebound, of not more than **0.01 inch/ton (0.25 mm/907 kg)** of test load.
  - b. Total settlement exceeds the pile elastic compression by **0.15 inch (4 mm)**, plus 1.0 percent of the tip diagonal dimension.
  - c. A plunging failure or sharp break in the load settlement curve.
7. Test Pile-Driving Records: Prepare driving records for each test pile, compiled and attested to by a qualified professional engineer, **as directed**. Include same data as required for driving records of permanent piles.
8. Test piles that comply with requirements, including location tolerances, may be used on Project.

D. Driving Piles

1. General: Continuously drive piles to elevations or penetration resistance indicated or established by static load testing of piles, **as directed**. Establish and maintain axial alignment of leads and piles before and during driving.
2. Spudding: Drive spud piles through overlying highly resistant strata or obstructions and withdraw for reuse.
3. Predrilling, **as directed**: Provide pre-excavated holes where indicated, to depths indicated. Drill holes with a diameter less than the largest cross-section dimension of pile.
  - a. Firmly seat pile in predrilled hole by driving with reduced energy before starting final driving.
4. Heaved Piles: Redrive heaved piles to tip elevation at least as deep as original tip elevation with a driving resistance at least as great as original driving resistance.
5. Driving Tolerances: Drive piles without exceeding the following tolerances, measured at pile heads:
  - a. Location: **4 inches (102 mm)** from location indicated after initial driving, and **6 inches (152 mm)** after pile driving is completed.
  - b. Plumb: Maintain **1 inch (25 mm)** in **4 feet (1.2 m)** from vertical, or a maximum of **4 inches (102 mm)**, measured when pile is aboveground in leads.
  - c. Batter Angle: Maximum **1 inch (25 mm)** in **4 feet (1.2 m)** from required angle, measured when pile is aboveground in leads.
6. Withdraw damaged or defective piles and piles that exceed driving tolerances and install new piles within driving tolerances.



- a. Fill holes left by withdrawn piles using cohesionless soil material such as gravel, broken stone, and gravel-sand mixtures. Place and compact in lifts not exceeding **72 inches (1.83 m)**.

**OR**

Fill holes left by withdrawn piles as directed by the Owner.

**OR**

Abandon and cut off rejected piles as directed by the Owner. Leave rejected piles in place and install new piles in locations as directed by the Owner.

- 7. Cutting Off: Cut off butts of driven piles square with pile axis and at elevations indicated.
  - a. Cover cut-off piling surfaces with caps overlapping pile end by minimum **2 inches (51 mm)** **OR** minimum three coats of preservative treatment, **as directed**, according to AWP4 M4.
- 8. Pile-Driving Records: Maintain accurate driving records for each pile, compiled and attested to by a qualified professional engineer, **as directed**. Include the following data:
  - a. Project name and number.
  - b. Name of Contractor.
  - c. Pile species.
  - d. Pile location in pile group and designation of pile group.
  - e. Sequence of driving in pile group.
  - f. Pile dimensions.
  - g. Ground elevation.
  - h. Elevation of tips after driving.
  - i. Final tip and cutoff elevations of piles after driving pile group.
  - j. Records of re-driving.
  - k. Elevation of splices.
  - l. Type, make, model, and rated energy of hammer.
  - m. Weight and stroke of hammer.
  - n. Type of pile-driving cap used.
  - o. Cushion material and thickness.
  - p. Actual stroke and blow rate of hammer.
  - q. Pile-driving start and finish times, and total driving time.
  - r. Time, pile-tip elevation, and reason for interruptions.
  - s. Number of blows for every **12 inches (305 mm)** of penetration, and number of blows per **1 inch (25 mm)** for the last **6 inches (152 mm)** of driving.
  - t. Pile deviations from location and plumb.
  - u. Preboring, jetting, or special procedures used.
  - v. Unusual occurrences during pile driving.

E. Field Quality Control

- 1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
  - a. Pile foundations.
- 2. Testing Agency: Engage a qualified independent testing agency to perform tests and inspections.
- 3. Tests and Inspections:
  - a. Dynamic Pile Testing: High-strain dynamic monitoring shall be performed and reported according to ASTM D 4945 during initial driving and during restriking on five single piles **OR** 3 percent of piles, **as directed**.

F. Disposal

- 1. Remove withdrawn piles and cutoff sections of piles from site and legally dispose of them off Owner's property.

END OF SECTION 31 62 19 00



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Task	Specification	Specification Description
31 62 23 13	31 62 16 19	Concrete-Filled Steel Piles

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## SECTION 31 64 13 00 - DRILLED PIERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for drilled piers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Dry-installed drilled piers.
  - b. Slurry displacement-installed drilled piers.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Design Mixtures: For each concrete mixture.
3. Shop Drawings: For concrete reinforcement.
4. Welding certificates.
5. Material certificates **OR** test reports, **as directed**.

#### D. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to the following:
  - a. AWS D1.1/D1.1M, "Structural Welding Code - Steel."
  - b. AWS D1.4, "Structural Welding Code - Reinforcing Steel."
2. Drilled-Pier Standard: Comply with ACI 336.1 unless modified in this Section.
3. Preinstallation Conference: Conduct conference at Project site.

#### E. Project Conditions

1. Existing Utilities: Locate existing underground utilities before excavating drilled piers. If utilities are to remain in place, provide protection from damage during drilled-pier operations.
  - a. Should uncharted or incorrectly charted piping or other utilities be encountered during excavation, adapt drilling procedure if necessary to prevent damage to utilities. Cooperate with the Owner and utility companies in keeping services and facilities in operation without interruption. Repair damaged utilities to satisfaction of utility the Owner.
2. Interruption of Existing Utilities: Do not interrupt any utility to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed interruption of utility.
  - b. Do not proceed with interruption of utility without the Owner's written permission.
3. Survey Work: Engage a qualified land surveyor or professional engineer to perform surveys, layouts, and measurements for drilled piers. Before excavating, lay out each drilled pier to lines and levels required. Record actual measurements of each drilled pier's location, shaft diameter, bottom and top elevations, deviations from specified tolerances, and other specified data.
  - a. Record and maintain information pertinent to each drilled pier and cooperate with the Owner's testing and inspecting agency to provide data for required reports.

### 1.2 PRODUCTS

#### A. Steel Reinforcement

1. Reinforcing Bars: ASTM A 615/A 615M, **Grade 60 (Grade 420)**, deformed.
2. Low-Alloy-Steel Reinforcing Bars: ASTM A 706/A 706M, deformed.

3. Galvanized Reinforcing Bars: ASTM A 615/A 615M, **Grade 60** (**Grade 420**) **OR** ASTM A 706/A 706M, **as directed**, deformed bars, ASTM A 767/A 767M, Class I **OR** Class II, **as directed**, zinc coated after fabrication and bending.
4. Epoxy-Coated Reinforcing Bars: ASTM A 615/A 615M, **Grade 60** (**Grade 420**) **OR** ASTM A 706/A 706M, **as directed**, deformed bars, ASTM A 775/A 775M or ASTM A 934/A 934M, epoxy coated, with less than 2 percent damaged coating in each **12-inch** (**300-mm**) bar length.
5. Plain-Steel Wire: ASTM A 82, as drawn **OR** galvanized, **as directed**.
6. Deformed-Steel Wire: ASTM A 496.
7. Epoxy-Coated Wire: ASTM A 884/A 884M, Class A, Type 1 coated, as-drawn, plain **OR** deformed, **as directed**, steel wire, with less than 2 percent damaged coating in each **12-inch** (**300-mm**) wire length.
8. Joint Dowel Bars: ASTM A 615/A 615M, **Grade 60** (**Grade 420**), plain. Cut bars true to length with ends square and free of burrs.

B. Concrete Materials

1. Cementitious Material: Use the following cementitious materials, of same type, brand, and source, throughout Project:
  - a. Portland Cement: ASTM C 150, Type I **OR** Type II **OR** Type I/II **OR** Type III **OR** Type V, **as directed**. Supplement with the following, **as directed**:
    - 1) Fly Ash: ASTM C 618, Class C **OR** Class F, **as directed**.
    - 2) Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
  - b. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag **OR** Type IP, portland-pozzolan **OR** Type I (PM), pozzolan-modified portland **OR** Type I (SM), slag-modified Portland, **as directed**, cement.
2. Normal-Weight Aggregate: ASTM C 33, graded, **3/4-inch-** (**19-mm-**) nominal maximum coarse-aggregate size.
  - a. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
3. Water: ASTM C 94/C 94M and potable.
4. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride.
  - a. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
  - b. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
  - c. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
  - d. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.
5. Sand-Cement Grout: Portland cement, ASTM C 150, Type II; clean natural sand, ASTM C 404; and water to result in grout with a minimum 28-day compressive strength of **1000 psi** (**6.9 MPa**), of consistency required for application.

C. Steel Casings

1. Steel Pipe Casings: ASTM A 283/A 283M, Grade C, or ASTM A 36/A 36M, carbon-steel plate, with joints full-penetration welded according to AWS D1.1/D1.1M.
2. Corrugated-Steel Pipe Casings: ASTM A 929/A 929M, steel sheet, zinc coated.
3. Liners: Comply with ACI 336.1.

D. Slurry

1. Slurry: Pulverized bentonite, pulverized attapulgite, or polymers mixed with water to form stable colloidal suspension; complying with ACI 336.1 for density, viscosity, sand content, and pH.

E. Concrete Mixtures

1. Prepare design mixtures for each type and strength of concrete, proportioned on the basis of laboratory trial mixture or field test data, or both, according to ACI 301.
2. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 limits as if concrete were exposed to deicing chemicals.

3. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 **OR** 0.30, **as directed**, percent by weight of cement.
4. Proportion normal-weight concrete mixture as follows:
  - a. Compressive Strength (28 Days): **6000 psi (41.4 MPa) OR 5000 psi (34.5 MPa) OR 4500 psi (31 MPa) OR 4000 psi (27.6 MPa) OR 3500 psi (24.1 MPa) OR 3000 psi (20.7 MPa), as directed.**
  - b. Maximum Water-Cementitious Materials Ratio: 0.50 **OR** 0.45 **OR** 0.40, **as directed.**
  - c. Minimum Slump: Capable of maintaining the following slump until completion of placement:
    - 1) **4 inches (100 mm)** for dry, uncased, or permanent-cased drilling method.
    - 2) **6 inches (150 mm)** for temporary-casing drilling method.
    - 3) **7 inches (175 mm)** for slurry displacement method.
  - d. Air Content: Do not air entrain concrete.

F. Fabricating Reinforcement

1. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

G. Concrete Mixing

1. Ready-Mixed Concrete: Measure, batch, mix, and deliver concrete according to ASTM C 94/C 94M, and furnish batch ticket information.
  - a. When air temperature is between **85 and 90 deg F (30 and 32 deg C)**, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above **90 deg F (32 deg C)**, reduce mixing and delivery time to 60 minutes.

### 1.3 EXECUTION

A. Preparation

1. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, vibration, and other hazards created by drilled-pier operations.

B. Excavation

1. Unclassified Excavation: Excavate to bearing elevations regardless of character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.
  - a. Obstructions: Unclassified excavation may include removal of unanticipated boulders, concrete, masonry, or other subsurface obstructions. No changes in the Contract Sum or the Contract Time will be authorized for removal of obstructions.
2. Classified Excavation: Excavation is classified as standard excavation, special excavation, and obstruction removal and includes excavation to bearing elevations as follows:
  - a. Standard excavation includes excavation accomplished with conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work.
  - b. Special excavation includes excavation that requires special equipment or procedures above or below indicated depth of drilled piers where drilled-pier excavation equipment used in standard excavation, operating at maximum power, torque, and downthrust, cannot advance the shaft.
    - 1) Special excavation requires use of special rock augers, core barrels, air tools, blasting, or other methods of hand excavation.
    - 2) Earth seams, rock fragments, and voids included in rock excavation area will be considered rock for full volume of shaft from initial contact with rock.
  - c. Obstructions: Payment for removing unanticipated boulders, concrete, masonry, or other subsurface obstructions that cannot be removed by conventional augers fitted with soil or rock teeth, drilling buckets, or underreaming tools attached to drilling equipment of size, power, torque, and downthrust necessary for the Work will be according to Contract provisions for changes in the Work.

3. Prevent surface water from entering excavated shafts. Conduct water to site drainage facilities.
4. Excavate shafts for drilled piers to indicated elevations. Remove loose material from bottom of excavation.
  - a. Excavate bottom of drilled piers to level plane within 1:12 tolerance.
  - b. Remove water from excavated shafts before concreting.
  - c. Excavate rock sockets of dimensions indicated.
  - d. Cut series of grooves about perimeter of shaft to height from bottom of shaft, vertical spacing, and dimensions indicated.
5. Notify and allow testing and inspecting agency to test and inspect bottom of excavation. If unsuitable bearing stratum is encountered, make adjustments to drilled piers as determined by the Owner.
  - a. Do not excavate shafts deeper than elevations indicated unless approved by the Owner.
  - b. Payment for additional authorized excavation will be according to Contract provisions for changes in the Work.
6. End-Bearing Drilled Piers: If further exploration below bearing elevation is required for end-bearing piers or if soft soils are suspected, probe with auger to a depth below bearing elevation, equal to diameter of the bearing area of drilled pier. Determine whether voids, clay seams, or solution channels exist.
  - a. Fill auger-probe holes with grout.
7. End-Bearing Drilled Piers: If drilled piers bear on clay or hardpan, probe with auger to a depth of **96 inches (2450 mm)** below bottom elevation of shaft, and visually inspect and classify soil. Verify continuity and thickness of stratum.
8. Excavate shafts for closely spaced drilled piers and for drilled piers occurring in fragile or sand strata only after adjacent drilled piers are filled with concrete and allowed to set.
9. Slurry Displacement Method: Stabilize excavation with slurry maintained a minimum of **60 inches (1500 mm)** above ground-water level and above unstable soil strata to prevent caving or sloughing of shaft. Maintain slurry properties before concreting.
  - a. Excavate and complete concreting of drilled pier on same day if possible, or redrill, clean, and test slurry in excavation before concreting.
  - b. Clean bottom of each shaft before concreting.
10. Temporary Casings: Install watertight steel casings of sufficient length and thickness to prevent water seepage into shaft; to withstand compressive, displacement, and withdrawal stresses; and to maintain stability of shaft walls.
  - a. Remove temporary casings, maintained in plumb position, during concrete placement and before initial set of concrete, or leave temporary casings in place, **as directed**.
11. Bells: Excavate bells for drilled piers to shape, base thickness, and slope angle indicated. Excavate bottom of bells to level plane and remove loose material before placing concrete.
  - a. Shore bells in unstable soil conditions to prevent cave-in during excavation, inspection, and concreting.
12. Tolerances: Construct drilled piers to remain within ACI 336.1 tolerances.
  - a. If location or out-of-plumb tolerances are exceeded, provide corrective construction. Submit design and construction proposals to the Owner for review before proceeding.

C. Permanent Steel Casings

1. Install steel casings of minimum wall thickness indicated and of diameter not less than diameter of drilled pier.
  - a. Install casings as excavation proceeds, to maintain sidewall stability.
  - b. Fabricate bottom edge of lowest casing section with cutting shoe capable of penetrating rock and achieving water seal.
  - c. Connect casing sections by continuous penetration welds to form watertight, continuous casing.
  - d. Remove and replace or repair casings that have been damaged during installation and that could impair strength or efficiency of drilled pier.
  - e. Fill annular void between casing and shaft wall with grout.



2. Corrugated-Steel Casings: Provide corrugated-steel casings formed from zinc-coated steel sheet.
  - a. Corrugated casings may be delivered in sections or panels of convenient length and field connected according to manufacturer's written instructions.
- D. Steel Reinforcement
  1. Comply with recommendations in CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
  2. Clean reinforcement of loose rust and mill scale, earth, and other materials that reduce or destroy bond with concrete.
  3. Fabricate and install reinforcing cages symmetrically about axis of shafts in a single unit.
  4. Accurately position, support, and secure reinforcement against displacement during concreting. Maintain minimum cover over reinforcement.
  5. Use templates to set anchor bolts, leveling plates, and other accessories furnished in work of other Sections. Provide blocking and holding devices to maintain required position during final concrete placement.
  6. Protect exposed ends of extended reinforcement, dowels, or anchor bolts from mechanical damage and exposure to weather.
- E. Concrete Placement
  1. Place concrete in continuous operation and without segregation immediately after inspection and approval of shaft by the Owner's independent testing and inspecting agency.
    - a. Construct a construction joint if concrete placement is delayed more than one hour. Level top surface of concrete and insert joint dowel bars, **as directed**. Before placing remainder of concrete, clean surface laitance, roughen, and slush concrete with commercial bonding agent or with sand-cement grout mixed at ratio of 1:1.
  2. Dry Method: Place concrete to fall vertically down the center of drilled pier without striking sides of shaft or steel reinforcement.
    - a. Where concrete cannot be directed down shaft without striking reinforcement, place concrete with chutes, tremies, or pumps.
    - b. Vibrate top **60 inches (1500 mm)** of concrete.
  3. Slurry Displacement Method: Place concrete in slurry-filled shafts by tremie methods or pumping. Control placement operations to ensure that tremie or pump pipe is embedded no fewer than **60 inches (1500 mm)** into concrete and that flow of concrete is continuous from bottom to top of drilled pier.
  4. Coordinate withdrawal of temporary casings with concrete placement to maintain at least a **60-inch (1500-mm)** head of concrete above bottom of casing.
    - a. Vibrate top **60 inches (1500 mm)** of concrete after withdrawal of temporary casing.
  5. Screed concrete at cutoff elevation level and apply scoured, rough finish. Where cutoff elevation is above the ground elevation, form top section above grade and extend shaft to required elevation.
  6. Protect concrete work, according to ACI 301, from frost, freezing, or low temperatures that could cause physical damage or reduced strength.
    - a. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
    - b. Do not use calcium chloride, salt, or other mineral-containing antifreeze agents or chemical accelerators.
  7. If hot-weather conditions exist that would seriously impair quality and strength of concrete, place concrete according to ACI 301 to maintain delivered temperature of concrete at no more than **90 deg F (32 deg C)**.
    - a. Place concrete immediately on delivery. Keep exposed concrete surfaces and formed shaft extensions moist by fog sprays, wet burlap, or other effective means for a minimum of seven days.
- F. Field Quality Control



1. Special Inspections: Engage a qualified special inspector to perform the following special inspections:
  - a. Drilled piers.
  - b. Excavation.
  - c. Concrete.
  - d. Steel reinforcement welding.
2. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
3. Drilled-Pier Tests and Inspections: For each drilled pier, before concrete placement.
  - a. Soil Testing: Bottom elevations, bearing capacities, and lengths of drilled piers indicated have been estimated from available soil data. Actual elevations and drilled-pier lengths and bearing capacities will be determined by testing and inspecting agency. Final evaluations and approval of data will be determined by the Owner.
    - 1) Bearing Stratum Tests: Testing agency will take undisturbed hardpan **OR** rock, **as directed**, core samples from drilled-pier bottoms and test each sample for compression, moisture content, and density, and will report results and evaluations.
4. Concrete Tests and Inspections: ASTM C 172 except modified for slump to comply with ASTM C 94/C 94M.
  - a. Slump: ASTM C 143/C 143M; one test at point of placement for each compressive-strength test but no fewer than one test for each concrete load.
  - b. Concrete Temperature: ASTM C 1064/C 1064M; 1 test hourly when air temperature is **40 deg F (4.4 deg C)** and below and **80 deg F (27 deg C)** and above, and 1 test for each set of compressive-strength specimens.
  - c. Compression Test Specimens: ASTM C 31/C 31M; one set of four standard cylinders for each compressive-strength test unless otherwise indicated. Mold and store cylinders for laboratory-cured test specimens unless field-cured test specimens are required.
  - d. Compressive-Strength Tests: ASTM C 39; one set for each drilled pier but not more than one set for each truck load. One specimen will be tested at 7 days, 2 specimens will be tested at 28 days, and 1 specimen will be retained in reserve for later testing if required.
  - e. If frequency of testing will provide fewer than five strength tests for a given class of concrete, testing will be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
  - f. If strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
  - g. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than **500 psi (3.4 MPa)**.
  - h. Report test results in writing to the Owner, concrete manufacturer, and Contractor within 48 hours of testing. List Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests in reports of compressive-strength tests.
  - i. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the Owner but will not be used as sole basis for approval or rejection of concrete.
  - j. Additional Tests: Testing and inspecting agency will make additional tests of concrete if test results indicate that slump, compressive strengths, or other requirements have not been met, as directed by the Owner.
    - 1) Continuous coring of drilled piers may be required, at Contractor's expense, if temporary casings have not been withdrawn within specified time limits or if observations of placement operations indicate deficient concrete quality, presence of voids, segregation, or other possible defects.

- k. Perform additional testing and inspecting, at Contractor's expense, to determine compliance of replaced or additional work with specified requirements.
- l. Correct deficiencies in the Work that test reports and inspections indicate do not comply with the Contract Documents.
- 5. An excavation, concrete, or a drilled pier will be considered defective if it does not pass tests and inspections.
- 6. Prepare test and inspection reports for each drilled pier as follows:
  - a. Actual top and bottom elevations.
  - b. Actual drilled-pier diameter at top, bottom, and bell.
  - c. Top of rock elevation.
  - d. Description of soil materials.
  - e. Description, location, and dimensions of obstructions.
  - f. Final top centerline location and deviations from requirements.
  - g. Variation of shaft from plumb.
  - h. Shaft excavating method.
  - i. Design and tested bearing capacity of bottom.
  - j. Depth of rock socket.
  - k. Levelness of bottom and adequacy of cleanout.
  - l. Properties of slurry and slurry test results at time of slurry placement and at time of concrete placement.
  - m. Ground-water conditions and water-infiltration rate, depth, and pumping.
  - n. Description, purpose, length, wall thickness, diameter, tip, and top and bottom elevations of temporary or permanent casings. Include anchorage and sealing methods used and condition and weather tightness of splices if any.
  - o. Description of soil or water movement, sidewall stability, loss of ground, and means of control.
  - p. Bell dimensions and variations from original design.
  - q. Date and time of starting and completing excavation.
  - r. Inspection report.
  - s. Condition of reinforcing steel and splices.
  - t. Position of reinforcing steel.
  - u. Concrete placing method, including elevation of consolidation and delays.
  - v. Elevation of concrete during removal of casings.
  - w. Locations of construction joints.
  - x. Concrete volume.
  - y. Concrete testing results.
  - z. Remarks, unusual conditions encountered, and deviations from requirements.
- G. Disposal Of Surplus And Waste Materials
  - 1. Disposal: Remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Owner's property.

END OF SECTION 31 64 13 00

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## SECTION 31 66 15 00 - RESISTANCE PIER SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of 2-Piece Resistance Piers. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Scope of Work: The work includes, but is not limited, to the following:

1. All soil excavation;
2. Preparation of the footing and stem wall or foundation grade beam;
3. Installation of the Pier Bracket including concrete anchors;
4. Mounting of the Drive Stand Assembly and the installation of steel Pier Sections to designed specifications;
5. Installation of the Top Pier Platform and Two Piece Lift Head Assembly;
6. Lifting of the structure with hydraulic rams and the restoration of the structure to a permanent elevation;
7. Replacement of the soil and general site clean-up.

### 1.2 PRODUCTS

#### A. Pier Bracket

1. Standard 2-Piece Pier Bracket (2-7/8" Diameter Pier Pipe): The Pier Bracket shall be a welded assembly of 5/8 and 1/2 inch thick flame cut steel plates conforming to ASTM A36, A568 and A569. The Pier Bracket shall provide 69 square inches of bearing surface against the bottom of the footing and a minimum of 48 square inches against the vertical face of the foundation. The Pier Bracket shall have guides for the top pier platform, two 9/16 inch diameter bracket mounting holes, two 11/16 inch diameter pier pin holes and four 1-1/32 inch diameter alignment and equipment mounting holes.
2. Standard 2-Piece Pier Bracket (3-1/2" & 4" Diameter Pier Pipe): The Pier Bracket for the 3-1/2 inch or 4-inch diameter pier shall be a welded assembly of 5/8 and 1/2 inch thick flame cut steel plates conforming to ASTM A36, A568 and A569. The Pier Bracket shall provide 74 square inches of bearing surface against the bottom of the footing and a minimum of 59 square inches against the vertical face of the foundation. The Pier Bracket shall have guides for the Top Pier Platform, two 9/16 inch diameter bracket mounting holes, two 11/16 inch diameter pier pin holes and six 1-1/32 inch diameter alignment and equipment mounting holes.
3. Heavy Duty 2-Piece Pier Bracket (4-1/2" Diameter Pier Pipe): The Pier Bracket shall be a welded assembly of 5/8 and 1/2 inch thick flame cut steel plates conforming to ASTM A36, A568 and A569. The Pier Bracket shall provide 74 square inches of bearing surface against the bottom of the footing and a minimum of 128 square inches against the vertical face of the foundation. The Pier Bracket shall have guides for the Top Pier Platform, four 9/16 inch diameter bracket mounting holes, two 7/8 inch diameter pier pin holes and six 1-1/32 inch diameter alignment and equipment mounting holes.
4. Flat Plate 2-Piece Pier Bracket (2-7/8", 3-1/2" & 4" Diameter Pier Pipe): The Pier Bracket shall be a welded assembly of 5/8 and 1/2-inch thick flame cut steel plates conforming to ASTM A36, A568 and A569. The Pier Bracket shall provide 320 square inches of surface contact against a vertical face of the stem wall or column. The Pier Bracket shall have guides for the Top Pier Platform, four 1 inch and four 1-1/8 inch diameter bracket mounting holes, four 11/16 inch diameter pier pin holes and six 1-1/32 inch diameter alignment and equipment mounting holes.
5. Curved Plate 2-Piece Pier Bracket (2-7/8", 3-1/2" & 4" Diameter Pier Pipe): The Curved Plate series of Pier Brackets shall be constructed as specified in Paragraph A.1 above with the

exception that the plate that mounts against the circular column shall be rolled to conform to the diameter of the column.

**B. Anchor Bolts**

1. Standard Pier Anchor Bolts: Each Pier Bracket requires two 1/2 inch diameter by 5-1/2 inch long (minimum) steel concrete expansion bolts (Four required for the 4-1/2" Diameter Heavy Duty 2-Piece Pier), cadmium plated with an ultimate pull out capacity of 6,300 pounds, working load 2,400 pounds. Bolts are required for mounting only. The Anchor Bolts shall be supplied with a flat washer and nut.
2. Plate Pier Anchor Bolts: Each Pier Bracket requires two 1/2 inch diameter by 5-1/2 inch long (minimum), four 3/4 inch diameter by 7-1/2 inch long (minimum) and four 3/4 inch diameter (minimum) by 10 inch long (minimum) steel concrete expansion bolts, cadmium plated with an ultimate pull out capacity of 7,250 pounds (minimum) to achieve maximum capacity. (Lighter bolt design may be used with lighter load applications.) The Anchor Bolts shall be supplied with a flat washer and nut.

**C. Grout (Optional)**

1. Pressure Bearing Grout: Quick setting premixed mortar with a 4,500 psi (minimum), three day strength. Master Builder's 713 Non-Shrink Grout or equivalent.
2. Flowable Pipe Grout: Quick setting, neat cement flowable grout with a 4,000 psi (minimum), three day strength.
3. Flowable Grout Fill: The grout slurry shall consist of sand, soil or other suitable void fill material mixed with any recognized lubricant such as 12 per cent cement (2-1/2 sack mix), bentonite or other lubricant to promote proper flow characteristics.

- D. Drive Stand Assembly:** The Drive Stand Assembly shall be a welded steel frame with a double acting hydraulic actuator capable of pressing the 42 inch long steel Pier Sections through the soil to a load bearing strata. The Drive Stand Assembly shall be temporarily attached to the Pier Bracket by means of one inch diameter by 2-3/4 inch long high strength locking pins.

**E. Pier Section**

1. Pier Section (2-7/8" Diameter x 0.165" Wall Thickness): Each Pier Section shall be fabricated from a 2-7/8 inch outside diameter by 42-inch long mill rolled, induction heat treated steel section with a 0.165 inch wall thickness. Yield strength shall be 50,000 psi and tensile strength shall be 55,000 psi. The initial section shall have a 3-1/2 inch outside diameter collar welded to the lead end of the pipe to assist in reducing wall friction during driving of the pier to capacity. The Pier Sections that follow shall each have a Coupling welded to one end. Steel in this section shall conform to ASTM A513.
2. Standard Pier Section (3-1/2" Diameter x 0.160" Wall Thickness): Each Pier Section shall be fabricated from a 3-1/2 inch outside diameter by 42-inch long mill rolled galvanized steel section with a 0.160 inch wall thickness. Yield strength shall be 50,000 psi and tensile strength shall be 55,000 psi. A triple coat corrosion protection of zinc chromate and clear polymer coating shall be provided. The initial section shall have a 4 inch outside diameter collar welded to the lead end of the pipe to assist in reducing wall friction during driving of the pier to capacity. The Pier Sections that follow shall each have a Coupling welded to one end. Steel in this section shall conform to ASTM A53, A513, A588, and B6.
3. Pier Section (4" Diameter x 0.219" Wall Thickness): Each Pier Section shall be fabricated from a 4 inch outside diameter by 42-inch long mill rolled steel section with a 0.219 inch wall thickness. Yield strength shall be 50,000 psi and tensile strength shall be 55,000 psi. The initial section shall have a 4-1/2 inch outside diameter collar welded to the lead end of the pipe to assist in reducing wall friction during driving of the pier to capacity. The Pier Sections that follow shall each have a Coupling welded to one end. Steel in this section shall conform to ASTM A513.
4. Heavy Duty Pier Section (4-1/2" Diameter x 0.238" Wall Thickness): Each Pier Section shall be fabricated from a 4-1/2 inch diameter, 0.238 wall thick pipe. Yield strength shall be 50,000 psi and tensile strength shall be 55,000 psi. The initial section shall have a 5 inch outside diameter

collar welded to the lead end of the pipe to assist in reducing wall friction during driving of the pier to capacity. The Pier Sections that follow shall each have a Coupling welded to one end. Steel in this section shall conform to ASTM A513.

- F. Coupling: The Pier Coupling shall be a 6-inch long tubular steel section of suitable diameter to fit inside the Pier Section. The Coupling shall be inserted and attached 3 inches inside one end of each Pier Section that follows the initial Pier Section. The remaining 3 inches of the Coupling shall extend beyond the Pier Section. All components shall conform to ASTM A513. On the 3-1/2" Pier Pipe, the Coupling shall be attached by an embossed mechanical connection. On all other Pier Pipe sizes, the Coupling shall be attached by plug welding the Coupling to the Pier Pipe.
- G. Modified Sleeve Pier Section (Modified Pier Only): The Modified Sleeve Pier Section shall be fabricated from a 3-1/2 inch diameter, 0.216 inch thick wall or 4 inch diameter, 0.219 inch thick wall mill rolled steel pipe, by 42 inches long. The yield strength shall be 50,000 psi. The Pipe Sleeve shall be mounted over the last Pier Section and shall be used to increase the moment transfer capacity from the Top Pier Platform to the Pier Section. Steel in this section shall conform to ASTM A36.
- H. Pier Sleeving (Optional): Pier Sleeving shall be used to stiffen the segmented joints through areas of weak soils. Depending upon the product, the sleeve sections shall be fabricated from 3 inch diameter, schedule 40 pipe, or 4 inch diameter, 0.219 inch thick wall mill rolled steel pipe, or 4-1/2 inch diameter, 0.238 thick wall mill rolled steel pipe by 42 inches long. The Sleeving shall be driven over the Pier Sections in the area of weak soils. The Sleeving shall be installed in a manner that staggers the joints in the Pier with the joints in the Sleeving. Steel in this section shall conform to one or more of ASTM A53, A513, A588, B6.
- I. Top Pier Platform
  - 1. Top Pier Platform For Standard, Modified And Plate Piers: The Standard Pier Platform shall be a welded assembly consisting of an 18 inch long steel tube of suitable size to fit over the Pier Section that shall form the cap cylinder. The cap cylinder shall have two 10 inch long by 5/8 inch thick steel plates welded as vertical stabilizers to the sides of the steel cap cylinder. The top of the Top Pier Platform shall be a 1 inch thick steel plate welded to the top of the cap cylinder. All steel elements shall conform to ASTM A36.
  - 2. Top Pier Platform For 4-1/2" Diameter Piers: A 4 inch outside diameter by 20 inch long steel pipe shall be welded to the inside of a 4-1/2 outside diameter by 10 inch long steel pipe to form the cap cylinder. The cap cylinder shall have two 9-1/2 inch long by 5/8 inch thick steel plates welded as vertical stabilizers to the sides of the steel cap cylinder. At the top of the Top Pier Platform shall be a 1 inch thick steel plate welded to the top of the cap cylinder. All steel elements shall conform to ASTM A36.
- J. High Strength Pier Pins
  - 1. High Strength Pier Pins For Standard, Modified And Plate Piers: Two 5/8 inch diameter by three inch long high strength, heat treated cadmium plated Pier Pins are required per pier. The Pier Pins shall be capable of providing 55,000 pounds of ultimate shear resistance capacity in double shear configuration. Pier Pins shall be 10B21 Boron Steel and heat treated to RC36 +/- . Pins shall conform to ASTM A490.
  - 2. High Strength Pier Pins For 4-1/2" Diameter Piers: Two 3/4 inch diameter by 3-1/4 inch long high strength cadmium plated Pier Pins are required per pier. The Pier Pins are capable of providing a minimum 30,000 pounds of shear capacity at each point of shear. Pier Pins shall be equivalent to Grade 8.
- K. Lift Shims: The Lift Shims shall be 5/8 inch by 1-1/2 inch and either 7 gauge or 16 gauge cadmium plated hot rolled steel. Lift Shims shall be used as required. The steel shall conform to ASTM A36.
- L. Two Piece Lift Head Assembly: The Two Piece Lift Head shall be a welded assembly that consists of 5/8 inch thick and 1 inch thick steel plates and is capable of providing a minimum of 45,000 pounds resistance capacity. The Two Piece Lift Head Assembly shall be temporarily attached to the Pier

Bracket by means of one inch diameter by 2-3/4 inch long high strength locking pins that are inserted through matching 1-1/32 inch diameter holes.

- M. **Lateral Support Device:** The Lateral Support Device is a specialized tool used to provide a horizontal force to the bottom of the Pier Bracket during Pier Section installation. The Lateral Support Device shall help counteract the torque developed between the structure and the Pier Bracket during Pier Section installation. The Lateral Support Device is a welded assembly of steel plate and tubing that has an adjustable length by means of a hand actuated thread and by a steel pin inserted through adjustment holes in the Lateral Support Device.
- N. **Helical Outrigger Assembly (Optional):** The Helical Outrigger Assembly shall provide supplemental drive resistance when installing the Pier Sections. This optional assembly is for use on light structures with low structural integrity. It is also used to push the Pier Section through weak or unsuitable strata and to develop a higher factor of safety. The Helical Outrigger Assembly shall consist of Helical Anchors, Helical Extension Sections, Connector Pins and Extension Rods.
- O. **Weldments:** All welded connections shall conform to the requirements of the American Welding Society, "Structural Welding Code AWS D1.1", and applicable revisions.

### 1.3 EXECUTION

- A. **Exposure Of Footing Or Grade Beam:** An area shall be excavated immediately adjacent to the building foundation to expose the footing, bottom of the grade beam, stem wall or column to a width of at least 36 inches and at least 15 inches beneath the proposed elevation of the base of the Pier Bracket. A chipping hammer shall be used to smooth and prepare the foundation for mounting of the Pier Bracket. The vertical and bottom face of the footing, if applicable, shall, to the extent possible, be smooth and at right angles to each other. The spread footing, if present, shall be notched to allow the Pier Bracket to mount directly under the bearing load of the stem wall, or shall be core drilled to allow the Pier Pipe from the Plate Pier to be installed. DO NOT cut any reinforcing steel in the footing element without approval by the engineer. The surfaces shall be smooth, free of all dirt, debris, and loose concrete so as to provide firm bearing surfaces for the Pier Bracket.
- B. **Installation Of The Pier Bracket**
  - 1. **Installation Of The Standard & Heavy Duty Two Piece Pier Bracket**
    - a. The Pier Bracket shall be temporarily mounted to the Drive Stand Assembly using one inch diameter locking pins and retaining clips. This assembly shall be lowered into the excavation adjacent to the foundation. The Pier Bracket shall then be seated flush against the footing using a hydraulic actuator or ram. The Pier Bracket shall be then fastened to the footing with two expansion Anchor Bolts. If the Pier Bracket does not have continuous bearing support on either the vertical or horizontal face, then Pressure Bearing Grout shall be used to provide proper bearing prior to driving the pier. Care should be exercised to insure that the Drive Stand Assembly frame is aligned plumb prior to driving each Pier Section. A carpenter's level may be used to verify the vertical alignment.
    - b. Install a Lateral Support Device between the bottom front side of the Pier Bracket and the vertical wall of the excavation opposite the pier. During installation of the Pier Sections, maintain support against the Pier Bracket with the Lateral Support Device. If required, install the optional Helical Outrigger Assembly to provide Supplemental Drive Resistance at this time.
  - 2. **Installation Of The Two-Piece Plate Pier Bracket:** A bolt template shall be used to properly locate and align the Pier Bracket at the location directed by the designer or directly over the cored hole in the footing element, if present. Once the anchor bolt holes are located, the 8 bolts shall be installed to the vertical face. The Plate Pier Bracket shall be installed with the nuts and washers provided with the anchor bolts. The longer bolts mount to the lower holes. Follow manufacturer's recommendations for bolt installation and maintain maximum embedment of the bolts. If the Pier

Bracket does not have continuous bearing support on the vertical face, then Pressure Bearing Grout shall be used to provide proper bearing prior to driving the pier. Care should be exercised to insure that the Pier Bracket is aligned plumb. A carpenter's level may be used to verify the vertical alignment.

C. Driving And Testing Pier Sections

1. Driving Of Pier Sections: All Pier Sections shall be continuously driven by use of the Drive Stand Assembly. The initial Pier Section shall have the friction reduction collar on the bottom end. Additional Pier Sections shall be added as the pier driving operation continues. Driving of the Pier Sections will continue until rock or an equal bearing strata is reached.
2. Load Testing Pier Section
  - a. Using The Double Acting Hydraulic Actuator: The pier shall be driven using the Drive Stand Assembly and the double acting hydraulic actuator until the maximum operating pressure of the hydraulic cylinder is reached or until lift of the structure is achieved, whichever occurs first. If the maximum hydraulic cylinder operating pressure is reached without lifting the structure, load test the Pier Section per Paragraph b following.
  - b. Using A Hydraulic Ram: Load testing the Pier to a force greater than the capacity of the hydraulic cylinder shall be achieved by removing the double acting hydraulic actuator from the Drive Stand Assembly and replacing it with the Supplemental Block. Install a 25 or 50 ton hydraulic ram, depending upon test force required, between the last Pier Section and the Supplemental Block. The hydraulic ram shall be actuated with a hand pump until bearing strata is verified as defined by a maximum installation force of:
    - 45,000 lbs. for 2-7/8" Dia. x 0.165" 2-Piece Pier & Plate Pier,
    - 52,500 lbs. for 2-7/8" Dia. x 0.165" 2-Piece Modified Pier & Modified Plate Pier,
    - 65,000 lbs. for 3-1/2" Dia. x 0.160" 2-Piece Pier & Plate Pier,
    - 67,500 lbs. for 3-1/2" Dia. x 0.160" 2-Piece Modified Pier & Modified Plate Pier,
    - 71,250 lbs. for 4" Dia. x 0.219" 2-Piece Pier & Plate Pier
    - 75,000 lbs. for 4" Dia. x 0.219" 2-Piece Modified Pier & Modified Plate Pier
    - 82,500 lbs. for 4-1/2" Dia. Heavy Duty 2-Piece Pier;
 or until lift of the structure is achieved, whichever is less.
3. Drive Equipment Removal: The Drive Stand Assembly shall be then removed from the Pier Bracket by removing the one inch diameter locking pins. The optional Helical Outtrigger Assembly shall be removed at this time. (NOTE: If the 3-1/2" Diameter Modified Pier is being installed, or if the Pier is to be sleeved; perform the operations in Paragraph 4. following, before removing the Drive Stand Assembly.)
4. Cutting Final Pier Section: It is likely that the final installed Pier Section will have to be removed from the hole and cut to a length suitable to provide space for installing the Top Pier Platform. Mark and cut the Pier Section to the proper length using a metal cutting saw capable of a smooth cut at 90 degrees to the length of the Pier Section. After cutting to length, the final Pier Section is replaced.

- D. Driving Of Pipe Sleeve (Optional): Once the capacity of the pier is achieved, the Drive Stand Assembly shall be used to push the Modified Sleeving Pier Section or plain Pier Sleeving over the last Pier Section or sections. **Do not exceed the manufacturer's rated operating capacity for the hydraulic cylinder.** The joints between the Pier Sleeves shall be staggered with the Couplings on the Pier Sections. Once the Pipe Sleeve(s) are installed, the Drive Stand Assembly shall be removed from the Pier Bracket by removing the one inch diameter locking pins.

- E. Installing Pipe Grout (Optional): Once the pier is installed to load bearing stratum and cut to the proper elevation, a neat cement flowable grout may be installed to the pier pipe. The grout will increase the moment of inertia (stiffness) and corrosion resistance of the pier. The grout shall be introduced to the bottom of the pier by means of a tube inserted into the pier pipe. As the grout is pumped into the pier pipe the tube shall be removed as the elevation of the grout increases. The process shall be executed carefully so that air is not entrained into the grout.





- F. Installation Of The Top Pier Platform: The Top Pier Platform shall be installed over the last installed Pier Section. Align the vertical stabilizers within the channels on the legs of the Pier Bracket and tap the Top Pier Platform until it contacts the top of the final Pier Section. A small port shall be provided between the cap cylinder and the platform to verify contact.
- G. Installation Of The Two Piece Lift Head Assembly: The Two Piece Lift Head Assembly shall be temporarily attached to the Pier Bracket by aligning the holes in each assembly. The one inch diameter locking pins and clips are used to align and hold the two pieces together.
- H. Lifting And Holding: The lifting and holding operation is designed to raise the structure and to restore it to as close to the original elevation as the construction will allow. Normally this lift and hold operation is accomplished with several Pier placements simultaneously. Install one 25 or 30 ton hydraulic ram as required between the Two Piece Lift Head Assembly and the Top Pier Platform on each pier. Install 3-1/2 inch square pier shims or equal to reduce excess space between the ram and the Two Piece Lift Head Assembly. The rams shall be actuated simultaneously to raise the structure. Lifting shall continue until the structure is restored to its approximate original elevation or to design specifications. Once restored, install the cadmium plated Lift Shims above the vertical stabilizer plates of the Top Pier Platform. The 7 gauge shims shall always be used for this operation. The 16 gauge shims shall only be used for fine adjustments between the stack of shims and the bottom of the pier pin holes in the Pier Bracket. Install two High Strength Pier Pins into the holes in the Pier Bracket by tapping the High Strength Pier Pins into place. There must be a snug fit of the High Strength Pier Pins and the Lift Shims. The load is transferred to the Pier System by removing the pressure from the hydraulic rams. Remove the ram and then remove the one inch locking pins along with the Two Piece Lift Head Assembly from the Pier Bracket.
- I. Documentation: The installer shall carefully monitor the driving force applied to the Pier Sections as the pier is installed. It is recommended that the driving force be recorded at 3-1/2 foot unless directed otherwise by the Engineer. The form of the data may be as directed by the customer or the Engineer. The Lifting Force, Lift, and Pier Depth shall also be recorded and presented in a tabular form. In addition, the installer shall know and have the desired terminal pressure that will create the desired driving force approved by the Engineer prior to beginning the pier installation.
- J. Void Filling (Optional - Depends upon soil characteristics, structure, and amount of lift): After raising operations are complete, voids created between the foundation and underlying soil shall be filled using a low pressure injection of grout slurry. Injection shall be through holes through the foundation. The contractor shall inject the grout in such a manner as to completely fill the void without trapping pockets of air. When the operation is complete, the contractor shall repair the injection holes by filling the holes with high strength non-shrinking grout and finishing to reasonably match the existing surface textures and elevations.
- K. Clean Up: Once all of the equipment has been removed, the area shall be backfilled using the previously excavated soil. The backfill shall be made by placing no more than 8 inches of loose material in a lift and compacting that soil prior to placement of the next 8-inch lift. Sufficient lifts shall be used to restore the ground to its original elevation and density. Slope the soil contour for drainage away from the foundation.

END OF SECTION 31 66 15 00

## SECTION 32 01 11 53 - TRAFFIC COATINGS

### 1.1 GENERAL

#### A. Description Of Work:

1. This specification covers the furnishing and installation of materials for traffic coating. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes traffic coatings for the following applications:
  - a. Interior and exterior pedestrian traffic.
  - b. Vehicular traffic.
  - c. Pavement markings.

#### C. Submittals

1. Product Data: For each product indicated.
2. Shop Drawings: Show extent of each traffic coating. Include details for treating substrate joints and cracks, flashings, deck penetrations, and other termination conditions.
3. Samples: For each type of finish indicated.
4. Material test reports.
5. Material certificates.
6. Qualification data.
7. Maintenance data.
8. Warranty.
9. LEED Submittal:
  - a. Product Data for Credit EQ 4.2: For interior field-applied traffic coatings and pavement marking paints, including printed statement of VOC content.

#### D. Quality Assurance

1. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of traffic coatings required for this Project.
2. Fire-Test-Response Characteristics: Provide traffic coating materials with the fire-test-response characteristics as determined by testing identical products per test method below for deck type and slopes indicated by an independent testing and inspecting agency that is acceptable to authorities having jurisdiction.
  - a. Class A **OR B OR C, as directed**, roof covering per ASTM E 108 or UL 790.
3. Preinstallation Conference: Conduct conference at Project site.

#### E. Delivery, Storage, And Handling

1. Deliver materials in original packages and containers with seals unbroken and bearing manufacturer's labels showing the following information:
  - a. Manufacturer's brand name.
  - b. Type of material.
  - c. Directions for storage.
  - d. Date of manufacture and shelf life.
  - e. Lot or batch number.
  - f. Mixing and application instructions.
  - g. Color.
2. Store materials in a clean, dry location protected from exposure to direct sunlight. In storage areas, maintain environmental conditions within range recommended in writing by manufacturer.

#### F. Project Conditions

1. Environmental Limitations: Apply traffic coatings within the range of ambient and substrate temperatures recommended in writing by manufacturer. Do not apply traffic coatings to damp or wet substrates, when temperatures are below **40 deg F (5 deg C)**, when relative humidity exceeds 85 percent, or when temperatures are less than **5 deg F (3 deg C)** above dew point.
  - a. Do not apply traffic coatings in snow, rain, fog, or mist, or when such weather conditions are imminent during the application and curing period. Apply only when frost-free conditions occur throughout the depth of substrate.
2. Do not install traffic coating until items that will penetrate membrane have been installed.

G. Warranty

1. Special Warranty: Manufacturer's standard form in which traffic coating manufacturer agrees to repair or replace traffic coatings that deteriorate during the specified warranty period. Warranty does not include deterioration or failure of traffic coating due to unusual weather phenomena, failure of prepared and treated substrate, formation of new substrate cracks exceeding **1/16 inch (1.6 mm)** in width, fire, vandalism, or abuse by snowplow, maintenance equipment, and truck traffic.
  - a. Deterioration of traffic coatings includes the following:
    - 1) Adhesive or cohesive failures.
    - 2) Abrasion or tearing failures.
    - 3) Surface crazing or spalling.
    - 4) Intrusion of water, oils, gasoline, grease, salt, deicer chemicals, or acids into deck substrate.
  - b. Warranty Period: Five years from date of Final Completion.

1.2 PRODUCTS

A. Materials

1. Traffic Coatings: Complying with ASTM C 957.
2. Material Compatibility: Provide primers; base, intermediate, and topcoats; and miscellaneous materials that are compatible with one another and with substrate under conditions of service and application, as demonstrated by manufacturer based on testing and field experience.
3. VOC Content: Provide traffic coatings and pavement marking paints, for use inside the weatherproofing system, with VOC content of 150 g/L when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. Traffic Coating

1. Primer: Manufacturer's standard factory-formulated primer recommended for substrate and conditions indicated.
  - a. Material: Epoxy **OR** Urethane, **as directed**.
2. Preparatory and Base Coats: Single- or multicomponent, aromatic liquid urethane elastomer.
3. Intermediate Coat: Single- or multicomponent, aromatic liquid urethane elastomer **OR** Single- or multicomponent, aliphatic liquid urethane elastomer **OR** Liquid epoxy, **as directed**.
4. Topcoat: Single- or multicomponent, aromatic liquid urethane elastomer **OR** Single- or multicomponent, aliphatic liquid urethane elastomer **OR** Single- or multicomponent, aromatic liquid urethane elastomer with UV inhibitors **OR** Liquid epoxy, **as directed**.
  - a. Color: As selected by the Owner from manufacturer's full range.
5. Aggregate: Uniformly graded, washed silicon carbide sand **OR** Uniformly graded, washed silica sand **OR** Uniformly graded, washed flint shot silica **OR** Walnut shell granules **OR** Aluminum-oxide grit, **as directed**, of particle sizes, shape, and minimum hardness recommended in writing by traffic coating manufacturer.
  - a. Spreading Rate: As recommended by manufacturer for substrate and service conditions indicated, but not less than the following:
    - 1) Intermediate Coat: **8 to 10 lb/100 sq. ft. (3.6 to 4.5 kg/10 sq. m)** **OR** To refusal, **as directed**.

- 2) Topcoat: **8 to 10 lb/100 sq. ft. (3.6 to 4.5 kg/10 sq. m)** **OR** As required to achieve slip-resistant finish, **as directed**.

C. Miscellaneous Materials

1. Joint Sealants: As specified in Division 07 Section "Joint Sealants".
2. Sheet Flashing: Nonstaining.
  - a. Minimum Thickness: **60 mils (1.5 mm)** **OR** **50 mils (1.3 mm)**, **as directed**.
  - b. Material: Sheet material recommended in writing by traffic coating manufacturer **OR** Uncured neoprene sheet **OR** Cured neoprene sheet, **as directed**.
3. Adhesive: Contact adhesive recommended in writing by traffic coating manufacturer.
4. Reinforcing Strip: Fiberglass mesh recommended in writing by traffic coating manufacturer.

D. Pavement Markings

1. Pavement-Marking Paint: Alkyd-resin ready mixed, complying with AASHTO M 248, Type S **OR** N **OR** F, **as directed**.
  - a. Color: White **OR** Yellow **OR** As indicated, **as directed**.
    - 1) Use blue for spaces accessible to people with disabilities.
2. Pavement-Marking Paint: Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, with drying time of less than three **OR** 45, **as directed**, minutes.
  - a. Color: White **OR** Yellow **OR** As indicated, **as directed**.
    - 1) Use blue for spaces accessible to people with disabilities.
3. Glass Beads: AASHTO M 247, Type 1.

1.3 EXECUTION

A. Examination

1. Examine substrates, with Installer present, for compliance with requirements and for other conditions affecting performance of traffic coatings.
  - a. For the record, prepare written report, endorsed by Installer, listing conditions detrimental to performance.
  - b. Verify compatibility with and suitability of substrates.
  - c. Begin coating application only after minimum concrete curing and drying period recommended by traffic coating manufacturer has passed, after unsatisfactory conditions have been corrected, and after surfaces are dry.
  - d. Verify that substrates are visibly dry and free of moisture.
    - 1) Test for moisture vapor transmission by plastic sheet method according to ASTM D 4263.
    - 2) Test for moisture content by measuring with an electronic moisture meter **OR** method recommended in writing by manufacturer, **as directed**.
  - e. Application of coating indicates acceptance of surfaces and conditions.

B. Preparation

1. Clean and prepare substrates according to ASTM C 1127 and manufacturer's written recommendations to produce clean, dust-free, dry substrate for traffic coating application.
2. Mask adjoining surfaces not receiving traffic coatings, deck drains, and other deck substrate penetrations to prevent spillage, leaking, and migration of coatings.
3. Concrete Substrates: Mechanically abrade concrete surfaces to a uniform profile according to ASTM D 4259. Do not acid etch.
  - a. Remove grease, oil, paints, and other penetrating contaminants from concrete.
  - b. Remove concrete fins, ridges, and other projections.
  - c. Remove laitance, glaze, efflorescence, curing compounds, concrete hardeners, form-release agents, and other incompatible materials that might affect coating adhesion.
  - d. Remove remaining loose material to provide a sound surface, and clean surfaces according to ASTM D 4258.

## C. Terminations And Penetrations

1. Prepare vertical and horizontal surfaces at terminations and penetrations through traffic coatings and at expansion joints, drains, and sleeves according to ASTM C 1127 and manufacturer's written recommendations.
2. Provide sealant cants at penetrations and at reinforced and nonreinforced, deck-to-wall butt joints.
3. Terminate edges of deck-to-deck expansion joints with preparatory base-coat strip.
4. Install sheet flashings at deck-to-wall expansion and dynamic joints, and bond to deck and wall substrates according to manufacturer's written recommendations.

## D. Joint And Crack Treatment

1. Prepare, treat, rout, and fill joints and cracks in substrates according to ASTM C 1127 and manufacturer's written recommendations. Before coating surfaces, remove dust and dirt from joints and cracks according to ASTM D 4258.
  - a. Comply with recommendations in ASTM C 1193 for joint-sealant installation.

## E. Traffic Coating Application

1. Apply traffic coating material according to ASTM C 1127 and manufacturer's written recommendations.
  - a. Start traffic coating application in presence of manufacturer's technical representative.
  - b. Verify that wet film thickness of each component coat complies with requirements every 100 sq. ft. (9 sq. m).
2. Apply traffic coatings to prepared wall terminations and vertical surfaces to height indicated, and omit aggregate on vertical surfaces.
3. Cure traffic coatings according to manufacturer's written recommendations. Prevent contamination and damage during application and curing stages.

## F. Pavement Markings

1. Do not apply traffic paint for striping and other markings until traffic coating has cured according to manufacturer's written recommendations.
2. Apply traffic paint for striping and other markings with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates for a 15-mil- (0.38-mm-) minimum wet film thickness.
3. Spread glass beads uniformly into wet traffic paint at a rate of 6 lb/gal. (0.72 kg/L).

## G. Field Quality Control

1. Testing: Engage a qualified testing agency to perform the following field tests and inspections and prepare test reports:
  - a. Samples of material delivered to Project site shall be taken, identified, sealed, and certified in presence of the Owner and Contractor.
  - b. Testing agency shall perform tests for characteristics specified, using applicable referenced testing procedures.
  - c. Testing agency shall verify thickness of coatings during traffic coating application.
  - d. If test results show traffic coating materials do not comply with requirements, remove noncomplying materials, prepare surfaces, and reapply traffic coatings.
2. Flood Testing: Flood test each deck area for leaks, according to recommendations in ASTM D 5957, after traffic coating has completely cured. Install temporary containment assemblies, plug or dam drains, and flood with potable water.
  - a. Flood to an average depth of 2-1/2 inches (65 mm) with a minimum depth of 1 inch (25 mm) and not exceeding a depth of 4 inches (100 mm).
  - b. Flood each area for 24 OR 48 OR 72, as directed, hours.
  - c. After flood testing, repair leaks, repeat flood tests, and make further repairs until traffic coating installation is watertight.
  - d. Engage an independent testing agency to observe flood testing and examine underside of decks and terminations for evidence of leaks during flood testing.

3. Final Traffic Coating Inspection: Arrange for traffic coating manufacturer's technical personnel to inspect membrane installation on completion.
    - a. Notify the Owner 48 hours in advance of date and time of inspection.
  4. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
- H. Protecting And Cleaning
1. Protect traffic coatings from damage and wear during remainder of construction period.
  2. Clean spillage from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

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Task	Specification	Specification Description
32 01 11 53	03 31 13 00	Cement Concrete Pavement

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## SECTION 32 01 13 61 - ASPHALT PAVING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for asphalt paving. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Cold milling of existing hot-mix asphalt pavement.
  - b. Hot-mix asphalt patching.
  - c. Hot-mix asphalt paving.
  - d. Hot-mix asphalt paving overlay.
  - e. Asphalt surface treatments.
  - f. Pavement-marking paint.
  - g. Traffic-calming devices.
  - h. Imprinted asphalt.

#### C. Definition

1. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

#### D. Submittals

1. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
  - a. Job-Mix Designs: Certification, by authorities having jurisdiction, of approval of each job mix proposed for the Work.
  - b. Job-Mix Designs: For each job mix proposed for the Work.
2. Material Certificates: For each paving material, from manufacturer.

#### E. Quality Assurance

1. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by authorities having jurisdiction or the DOT of state in which Project is located.
2. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of State or local DOT for asphalt paving work.
  - a. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.
3. Preinstallation Conference: Conduct conference at Project site.

#### F. Delivery, Storage, And Handling

1. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.
2. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

#### G. Project Conditions

1. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:
  - a. Prime Coat: Minimum surface temperature of 60 deg F (15.6 deg C).
  - b. Tack Coat: Minimum surface temperature of 60 deg F (15.6 deg C).

- c. Slurry Coat: Comply with weather limitations in ASTM D 3910.
- d. Asphalt Base Course: Minimum surface temperature of **40 deg F (4.4 deg C)** and rising at time of placement.
- e. Asphalt Surface Course: Minimum surface temperature of **60 deg F (15.6 deg C)** at time of placement.
- 2. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of **40 deg F (4.4 deg C)** for oil-based materials **OR 55 deg F (12.8 deg C)** for water-based materials, **as directed**, and not exceeding **95 deg F (35 deg C)**.
- 3. Imprinted Asphalt Paving: Proceed with coating imprinted pavement only when air temperature is at least **50 deg F (10 deg C)** and rising and will not drop below **50 deg F (10 deg C)** within 8 hours of coating application. Proceed only if no precipitation is expected within two hours after applying the final layer of coating.

## 1.2 PRODUCTS

### A. Aggregates

- 1. General: Use materials and gradations that have performed satisfactorily in previous installations.
- 2. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
- 3. Fine Aggregate: ASTM D 1073 or AASHTO M 29, sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
  - a. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.
- 4. Mineral Filler: ASTM D 242 or AASHTO M 17, rock or slag dust, hydraulic cement, or other inert material.

### B. Asphalt Materials

- 1. Asphalt Binder: AASHTO M 320 or AASHTO MP 1a, PG 64-22 **OR** PG 58-28 **OR** PG 70-22, **as directed**.
- 2. Asphalt Cement: ASTM D 3381 for viscosity-graded material **OR** ASTM D 946 for penetration-graded material, **as directed**.
- 3. Prime Coat:
  - a. ASTM D 2027, medium-curing cutback asphalt, MC-30 or MC-70 **OR** MC-250, **as directed**.  
**OR**  
Asphalt emulsion prime coat complying with State or local DOT requirements.
- 4. Tack Coat: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
- 5. Fog Seal: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.
- 6. Slurry Seal: ASTM D 3910, Type 1 **OR** Type 2 **OR** Type 3, **as directed**.
- 7. Chip Seal: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application. **RS-2 OR RS-2P OR CRS-2 OR CRS-2P OR HFRS-2 OR HFRS-2P, as directed.**
- 8. Sand Seal: AASHTO M 140 emulsified asphalt or AASHTO M 208 cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application. Sand shall meet the following gradation as tested by AASHTO T27.
- 9. Water: Potable.
- 10. Undersealing Asphalt: ASTM D 3141, pumping consistency.

C. Auxiliary Materials

1. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.
2. Sand: ASTM D 1073 or AASHTO M 29, Grade Nos. 2 or 3.
3. Paving Geotextile: AASHTO M 288, nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications.
4. Joint Sealant: ASTM D 6690 or AASHTO M 324, Type I **OR** Type II or III **OR** Type IV, **as directed**, hot-applied, single-component, polymer-modified bituminous sealant.
5. Pavement-Marking Paint: Color shall be White **OR** Yellow **OR** Blue, **as directed**.
  - a. Alkyd-resin type, lead and chromate free, ready mixed, complying with AASHTO M 248, Type N **OR** Type F **OR** Type S, **as directed**; colors complying with FS TT-P-1952.  
**OR**  
MPI #32 Alkyd Traffic Marking Paint.  
**OR**  
Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than three **OR** 45, **as directed**, minutes.  
**OR**  
MPI #97 Latex Traffic Marking Paint.
6. Glass Beads: AASHTO M 247, Type 1.
7. Wheel Stops:
  - a. Precast, air-entrained concrete, 2500-psi (17.2-MPa) minimum compressive strength, 4-1/2 inches (115 mm) high by 9 inches (225 mm) wide by 72 inches (1800 mm) long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.  
**OR**  
Solid, integrally colored, 96 percent recycled HDPE or commingled postconsumer and postindustrial recycled plastic; UV stabilized; 4 inches (100 mm) high by 6 inches (150 mm) wide by 72 inches (1800 mm) long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.
  - b. Dowels: Galvanized steel, 3/4-inch (19-mm) diameter, 10-inch (254-mm) minimum length.
  - c. Adhesive: As recommended by wheel-stop manufacturer for application to asphalt pavement.

D. Preformed Traffic-Calming Devices

1. Speed Bumps **OR** Humps **OR** Cushions, **as directed**: Solid, integrally colored, 100 percent postconsumer or commingled postconsumer and postindustrial recycled rubber **OR** plastic, **as directed**; UV stabilized. Provide holes for anchoring to substrate.
  - a. Size: Modular bumps 2 inches (51 mm) high by 10 inches (254 mm) wide by 72 inches (1800 mm) long, with overall length as dimensioned on Drawings.
  - b. Size: Modular assemblies 3 inches (76 mm) high by 12 feet (3.7 m) in overall width **OR** 4 inches (102 mm) high by 14 feet (4.3 m) in overall width, **as directed**, with overall length as dimensioned on Drawings.
  - c. Mounting Hardware: Galvanized-steel spike, 1/2-inch (13-mm) diameter, 10-inch (254-mm) minimum length **OR** lag screw, shield, and washers; 1/2-inch (13-mm) diameter, 8-inch (203-mm) minimum length **OR** hardware as standard with device manufacturer, **as directed**.
  - d. Adhesive: As recommended by device manufacturer.

E. Imprinted Asphalt Materials

1. Templates: Imprinted-asphalt manufacturer's standard flexible templates for imprinting pattern into hot asphalt paving.
  - a. Pattern: Running bond brick **OR** Cobblestone **OR** Custom pattern indicated on Drawings, **as directed**.
2. Coating System: Imprinted-asphalt manufacturer's standard system formulated for exterior application on asphalt paving surfaces.
  - a. Base Coating: Portland cement and epoxy-modified acrylic polymer blended with sand and aggregate, formulated for exterior application on asphalt paving surfaces.



- b. Top Coating: Epoxy-modified acrylic polymer blended with sand and aggregate, formulated for exterior application on asphalt paving surfaces.
- c. Colorant: UV-stable pigment blend, added to each coating layer.
- d. Color: White **OR** Yellow, **as directed**.
- 3. Precut Marking Material: Imprinted-asphalt manufacturer's standard, reflectorized, thermoplastic, **90-mil (2.3-mm)** minimum thickness, formulated for exterior application on asphalt paving surfaces, and matching the imprinted pattern of templates.

#### F. Mixes

- 1. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:
  - a. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
  - b. Base Course: In accordance with state or local DOT specifications.
  - c. Surface Course: In accordance with state or local DOT specifications.
- 2. Hot-Mix Asphalt Based on ASTM D 3515 Requirements: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction and designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types."
  - a. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
  - b. Provide mixes complying with composition, grading, and tolerance requirements in ASTM D 3515 for the following nominal, maximum aggregate sizes:
    - 1) Base Course: **1 inch (25 mm)**.
    - 2) Surface Course: **1/2 inch (13 mm)**.
- 3. Emulsified-Asphalt Slurry: ASTM D 3910, Type 1 **OR** Type 2 **OR** Type 3, **as directed**.

### 1.3 EXECUTION

#### A. Examination

- 1. Verify that subgrade is dry and in suitable condition to begin paving.
- 2. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.
  - a. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to **3 mph (5 km/h)**.
  - b. Proof roll with a loaded 10-wheel, tandem-axle dump truck weighing not less than **15 tons (13.6 tonnes)**.
  - c. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the Owner, and replace with compacted backfill or fill as directed.
- 3. Proceed with paving only after unsatisfactory conditions have been corrected.
- 4. Verify that utilities, traffic loop detectors, and other items requiring a cut and installation beneath the asphalt surface have been completed and that asphalt surface has been repaired flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

#### B. Cold Milling

- 1. Clean existing pavement surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement by cold milling to grades and cross sections indicated.
  - a. Mill to a depth of **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 3 inches (75 mm), as directed**.
  - b. Mill to a uniform finished surface free of excessive gouges, grooves, and ridges.
  - c. Control rate of milling to prevent tearing of existing asphalt course.
  - d. Repair or replace curbs, manholes, and other construction damaged during cold milling.

- e. Excavate and trim unbound-aggregate base course, if encountered, and keep material separate from milled hot-mix asphalt.
- f. Transport milled hot-mix asphalt to asphalt recycling facility.
- g. Keep milled pavement surface free of loose material and dust.

C. Patching

1. Hot-Mix Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending **12 inches (300 mm)** into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Recompact existing unbound-aggregate base course to form new subgrade.
2. Portland Cement Concrete Pavement: Break cracked slabs and roll as required to reseat concrete pieces firmly.
  - a. Pump hot undersealing asphalt under rocking slab until slab is stabilized or, if necessary, crack slab into pieces and roll to reseat pieces firmly.
  - b. Remove disintegrated or badly cracked pavement. Excavate rectangular or trapezoidal patches, extending into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Recompact existing unbound-aggregate base course to form new subgrade.
3. Tack Coat: Apply uniformly to vertical surfaces abutting or projecting into new, hot-mix asphalt paving at a rate of **0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m)**.
  - a. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
  - b. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
4. Patching:
  - a. Fill excavated pavements with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

**OR**

Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

D. Repairs

1. Leveling Course: Install and compact leveling course consisting of hot-mix asphalt surface course to level sags and fill depressions deeper than **1 inch (25 mm)** in existing pavements.
  - a. Install leveling wedges in compacted lifts not exceeding **3 inches (75 mm)** thick.
2. Crack and Joint Filling: Remove existing joint filler material from cracks or joints to a depth of **1/4 inch (6 mm)**.
  - a. Clean cracks and joints in existing hot-mix asphalt pavement.
  - b. Use emulsified-asphalt slurry to seal cracks and joints less than **1/4 inch (6 mm)** wide. Fill flush with surface of existing pavement and remove excess.
  - c. Use hot-applied joint sealant to seal cracks and joints more than **1/4 inch (6 mm)** wide. Fill flush with surface of existing pavement and remove excess.

E. Surface Preparation

1. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.
2. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.
  - a. Mix herbicide with prime coat if formulated by manufacturer for that purpose.
3. Prime Coat: Apply uniformly over surface of compacted unbound-aggregate base course at a rate of **0.15 to 0.50 gal./sq. yd. (0.7 to 2.3 L/sq. m)**. Apply enough material to penetrate and seal but not flood surface. Allow prime coat to cure.
  - a. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.





- b. Protect primed substrate from damage until ready to receive paving.
  4. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of **0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).**
    - a. Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.
    - b. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.
- F. Paving Geotextile Installation
  1. Apply tack coat **OR** asphalt binder **OR** asphalt cement, **as directed**, uniformly to existing pavement surfaces at a rate of **0.20 to 0.30 gal./sq. yd. (0.8 to 1.2 L/sq. m).**
  2. Place paving geotextile promptly according to manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints **4 inches (100 mm)** and transverse joints **6 inches (150 mm).**
    - a. Protect paving geotextile from traffic and other damage and place hot-mix asphalt paving overlay the same day.
- G. Hot-Mix Asphalt Placing
  1. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
    - a. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
    - b. Place hot-mix asphalt surface course in single lift.
    - c. Spread mix at minimum temperature of **250 deg F (121 deg C).**
    - d. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
    - e. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
  2. Place paving in consecutive strips not less than **10 feet (3 m)** wide unless infill edge strips of a lesser width are required.
    - a. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt base course before placing asphalt surface course.
  3. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.
- H. Joints
  1. Construct joints to ensure a continuous bond between adjoining paving sections. Construct joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.
    - a. Clean contact surfaces and apply tack coat to joints.
    - b. Offset longitudinal joints, in successive courses, a minimum of **6 inches (150 mm).**
    - c. Offset transverse joints, in successive courses, a minimum of **24 inches (600 mm).**
    - d. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations" **OR** as shown on Drawings, **as directed.**
    - e. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
    - f. Compact asphalt at joints to a density within 2 percent of specified course density.
- I. Compaction
  1. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

- a. Complete compaction before mix temperature cools to **185 deg F (85 deg C)**.
  2. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
  3. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:
    - a. Average Density:
      - 1) 96 percent of reference laboratory density according to ASTM D 6927 or AASHTO T 245, but not less than 94 percent nor greater than 100 percent.
      - OR**
      - 92 percent of reference maximum theoretical density according to ASTM D 2041, but not less than 90 percent nor greater than 96 percent.
  4. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
  5. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
  6. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.
  7. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.
  8. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.
- J. Asphalt Curbs
  1. Construct hot-mix asphalt curbs over compacted pavement surfaces. Apply a light tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of **250 deg F (121 deg C)**.
    - a. Asphalt Mix: Same as pavement surface-course mix.
  2. Place hot-mix asphalt to curb cross section indicated or, if not indicated, to local standard shapes, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.
- K. Asphalt Traffic-Calming Devices
  1. Construct hot-mix asphalt speed bumps, humps, cushions, and tables over compacted pavement surfaces. Apply a tack coat unless pavement surface is still tacky and free from dust. Spread mix at minimum temperature of **250 deg F (121 deg C)**.
    - a. Tack Coat Application: Apply uniformly to surfaces of existing pavement at a rate of **0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m)**.
    - b. Asphalt Mix: Same as pavement surface-course mix.
    - c. Before installation, mill pavement that will be in contact with bottom of traffic-calming device. Mill to a depth of **1 inch (25 mm)** from top of pavement to a clean, rough profile.
  2. Place hot-mix asphalt to cross section indicated, by machine or by hand in wood or metal forms. Tamp hand-placed materials and screed to smooth finish. Remove forms after hot-mix asphalt has cooled.
- L. Installation Tolerances
  1. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:
    - a. Base Course: Plus or minus **1/2 inch (13 mm)**.
    - b. Surface Course: Plus **1/4 inch (6 mm)**, no minus.
  2. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a **10-foot (3-m)** straightedge applied transversely or longitudinally to paved areas:
    - a. Base Course: **1/4 inch (6 mm)**.





- b. Surface Course: **1/8 inch (3 mm)**.
- c. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is **1/4 inch (6 mm)**.
- 3. Traffic-Calming Devices: Compact and form asphalt to produce the contour indicated and within a tolerance of plus or minus **1/8 inch (3 mm)** of height indicated above pavement surface.

M. Surface Treatments

- 1. Fog Seals: Apply fog seal at a rate of **0.10 to 0.15 gal./sq. yd. (0.45 to 0.7 L/sq. m)** to existing asphalt pavement and allow to cure. With fine sand, lightly dust areas receiving excess fog seal.
- 2. Slurry Seals: Apply slurry coat in a uniform thickness according to ASTM D 3910 and allow to cure.
  - a. Roll slurry seal to remove ridges and provide a uniform, smooth surface.
- 3. Chip Seals: Apply asphalt binder directly to the pavement followed by a layer of 1/4 inch aggregate chips **OR** as directed, and roll to embed aggregate into the binder.
  - a. Can be applied as double **OR** triple layers, **as directed**, which are accomplished by applying additional layers of asphaltic material and aggregate. After applying each layer of aggregate, the surface is compacted using a roller to embed aggregates in the binder.
- 4. Sand Seals: Spray emulsion directly to the pavement followed by a layer of sand. The sand can be spread immediately for maximum stick, **OR** wait until after the emulsion breaks and be rolled with a pneumatic tire roller, **as directed**.

N. Pavement Marking

- 1. Do not apply pavement-marking paint until layout, colors, and placement have been verified with the Owner.
- 2. Allow paving to age for 30 **OR** 90, **as directed**, days before starting pavement marking.
- 3. Sweep and clean surface to eliminate loose material and dust.
- 4. Apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of **15 mils (0.4 mm)**.
  - a. Broadcast glass beads uniformly into wet pavement markings at a rate of **6 lb/gal. (0.72 kg/L)**.

O. Wheel Stops

- 1. Install wheel stops in bed of adhesive as recommended by manufacturer.
- 2. Securely attach wheel stops to pavement with not less than two galvanized-steel dowels embedded at one-quarter to one-third points. Securely install dowels into pavement and bond to wheel stop. Recess head of dowel beneath top of wheel stop.

P. Preformed Traffic-Calming Devices

- 1. Install preformed speed bumps **OR** humps **OR** cushions, **as directed**, in bed of adhesive as recommended by manufacturer for heavy traffic.
- 2. Securely attach preformed speed bumps **OR** humps **OR** cushions, **as directed**, to pavement with hardware spaced as recommended by manufacturer for heavy traffic. Recess head of hardware beneath top surface.

Q. Imprinting Asphalt

- 1. General: Imprint asphalt according to manufacturer's written instructions, using manufacturer's recommended equipment.
- 2. Freshly Laid Asphalt: Immediately after asphalt has been laid and compacted but still plastic, begin the surface imprinting process.
  - a. Monitor asphalt surface temperature in compliance with manufacturer's written recommendations to ensure required temperature to perform surface imprinting.
  - b. Reheat asphalt if surface temperature drops below that required.
- 3. Reheating Asphalt: Soften asphalt pavement surface by heating to a depth of at least **1/2 inch (13 mm)** without burning asphalt.

- a. Heat to a temperature of **300 to 325 deg F (149 to 163 deg C)** immediately before applying templates.
  - b. Regularly monitor the pavement temperature to prevent overheating.
  - c. Direct flame heaters are not permitted.
  - d. If pavement is overheated and begins to emit black smoke, remove damaged pavement by milling down **1 inch (25 mm)** and replace removed pavement with new, compacted surface course prior to resuming imprinting work.
  4. Surface Imprinting: Apply and imprint templates to a minimum depth of **1/4 inch (6 mm)** **OR** as required to embed precut marking material flush or barely beneath pavement surface, **as directed**.
  5. Coating Application: After imprinted surface has cooled, apply two layers of base coating followed by two layers of top coating **OR** four layers of top coating, **as directed**. Do not allow traffic until coating has completely dried and cured.
  6. Precut Marking Material Application: Position precut marking material aligned with imprinted pattern and slowly heat to a temperature no higher than **325 deg F (163 deg C)** until marking material begins to liquefy and flow. Do not allow traffic until installed marking material has cooled to ambient temperature.
- R. Field Quality Control
1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
  2. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.
  3. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.
  4. Traffic-Calming Devices: Finished height of asphalt speed bumps, humps, cushions, and tables above pavement will be measured for compliance with tolerances.
  5. In-Place Density: Testing agency will take samples of uncompacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.
    - a. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
    - b. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.
      - 1) One core sample will be taken for every **1000 sq. yd. (836 sq. m)** or less of installed pavement, with no fewer than 3 cores taken.
      - 2) Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.
  6. Replace and compact hot-mix asphalt where core tests were taken.
  7. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.
- S. Disposal
1. Except for material indicated to be recycled, remove excavated materials from Project site and legally dispose of them in an EPA-approved landfill.
    - a. Do not allow milled materials to accumulate on-site.

END OF SECTION 32 01 13 61

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## SECTION 32 01 13 61a - CRACK SEALING OF BITUMINOUS PAVEMENTS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for crack sealing of bituminous pavements. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Manufacturer's Recommendations: Where installation procedures, or any part thereof, are required to be in accordance with the manufacturer's recommendations, printed copies of these recommendations shall be submitted to the Owner. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.
2. Schedules/Construction Equipment List: List of proposed equipment to be used in performance of construction work including descriptive data shall be submitted to the Owner.
3. Samples: Samples of the materials (sealant, primer if required, and backup material), in sufficient quantity for testing and approval shall be submitted to the Owner. No material will be allowed to be used until it has been approved.

- C. Safety: Joint sealant shall not be placed within 25 feet of any liquid oxygen (LOX) equipment, LOX storage, or LOX piping. Joints in this area shall be thoroughly cleaned and left unsealed.

- D. Test Requirements: The joint sealant and backup or separating material shall be tested for conformance with the referenced applicable material specification. Testing of the materials shall be performed in an approved independent laboratory and certified copies of the test reports shall be submitted and approved prior to the use of the materials at the job site. Samples will be retained by the Owner for possible future testing should the materials appear defective during or after application. Conformance with the requirements of the laboratory tests specified will not constitute final acceptance of the materials. Final acceptance will be based on the performance of the in-place materials.

- E. Equipment: Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and shall be maintained in satisfactory condition at all times.

### 1.2 PRODUCTS

#### A. Materials

1. Liquid Asphalt: ASTM D 2027, Grade MC-250.
2. Emulsified Asphalt: ASTM D 977, Grade AS-2.
3. Sealing Compound: ASTM D 3405.
4. Backer Rod: ASTM D 5249.
5. Fine Aggregate: Natural sand or crusher dust having a maximum size of not more than 1/8 inch and be free of clay or organic-matter.

### 1.3 EXECUTION

#### A. Preparation:

1. All cracks to be sealed shall be cleaned of dirt and debris, and moisture shall be removed.

2. Crack Cleaning Equipment shall consist of a portable air compressor with hose and nozzles for directing air directly into cracks and stiff bristle brooms.
3. Heating Equipment for Liquid Asphalt shall be mobile and shall be equipped with an agitating device for stirring material during heating, a thermometer, regulating equipment for heat control, and a gravity-type draw-off valve.
4. Heating Equipment for Sealing Compound: Unless otherwise required by the manufacturer's recommendations, the equipment shall be mobile and shall consist of double-boiler, agitator-type kettles with oil medium in the outer space for heat transfer. The applicator unit shall be so designed that the sealant will circulate through the delivery hose and return to the inner kettle when not sealing cracks.
5. Application Equipment shall have a spout or nozzle of such size that the sealing material will be placed in the cracks without entrapping air in cracks or spreading material on adjacent pavement surface.

B. Installation:

1. Backer Rod: Install backer in accordance with manufacturer's instructions where required under sealing compound.
2. Sealing Compound: All cracks 1/8 inch wide and wider shall be sealed. The application temperature for sealing compound shall comply with ASTM C 1193. Cracks 1/2 inch wide and wider shall be filled with a slurry of fine sand and an emulsified asphalt or liquid asphalt. After the slurry has cured, cracks shall be sealed with liquid asphalt or emulsified asphalt and lightly sanded.
3. Liquid and Emulsified Asphalt Sealer: The temperature shall be varied so that it flows freely into cracks and completely fills cracks without entrapping air. Cracks shall be free of moisture before filling and shall be filled slightly above the pavement surface. When excess sealer has been removed, the sealer shall be covered with fine sand.
4. Traffic Control: Traffic will not be permitted over sealed cracks until the sealer has cooled so that it is not picked up by vehicle tires. The Contractor will be responsible for all barricades and flagmen necessary to control traffic.

END OF SECTION 32 01 13 61a

## SECTION 32 01 13 61b - SPRAY APPLICATIONS, SEAL COATS, AND SURFACE TREATMENTS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for the spray applications, seal coats, and surface treatments of asphalt concrete pavements. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

- A. Bituminous Material: Bituminous material shall be liquid asphalt complying with ASTM D 2028, Grade RC-250, or tar complying with ASTM D 490, Grade RT-6.

- B. Aggregate: Aggregates shall consist of crushed stone, crushed gravel, or crushed slag. The moisture content of the aggregate shall be such that the aggregate will be readily coated with the bituminous material. Aggregate gradations shall be in compliance with ASTM C 136.

#### C. Construction Equipment

1. Bituminous Distributor shall be designed and equipped to distribute the bituminous material uniformly at even heat on variable widths of surface at readily determined and controlled rates and pressures recommended by the manufacturer and with an allowable variation from any specified rate not exceeding 5 percent.
2. Single-Pass Surface Treatment Machine shall be capable of distributing the bituminous material and aggregates uniformly in controlled amounts in a single-pass operation over the surface to be sealed.
3. Heating Equipment for Storage Tanks shall consist of steam coils, hot oil coils, or electrical coils. If steam or hot oil coils are used, the coils must be so designed and maintained that the bituminous material cannot become contaminated.
4. Power Rollers shall be the self-propelled tandem and three-wheel type rollers, weighing not less than 5 tons and shall be suitable for rolling bituminous pavements.
5. Self-Propelled Pneumatic-Tired rollers shall have a total compacting width of not less than 60 inches. The gross weight shall be adjustable within the ranges of 200 to 350 lb/in. of compacting width.
6. Spreading Equipment: Aggregate spreading equipment shall be adjustable and capable of spreading aggregate at controlled amounts per square yard.
7. Drags: Broom drags shall consist of brooms mounted on a frame, designed to spread fine aggregate uniformly over the surface of a bituminous pavement. Towing equipment shall have pneumatic tires.
8. Brooms and Blowers shall be of the power type and shall be suitable for cleaning surfaces of bituminous pavements.

### 1.3 EXECUTION

#### A. Installation

1. Spreading Aggregate: Application of seal aggregate shall immediately follow the application of bituminous material, and in no case shall the time to application exceed 15 minutes.



2. Brooming and Rolling: Begin the rolling operations immediately following the application of cover aggregate. Rolling shall be accomplished with pneumatic-tired rollers; steel-wheeled rollers shall be used in a supplementary capacity only. All surplus aggregate shall be swept off the surface and removed not less than 26 hours or more than four days after rolling is completed.

END OF SECTION 32 01 13 61b

NOT FOR BID

## SECTION 32 01 16 71 - GRINDING/GROOVING PAVEMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of grinding/grooving pavement. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS - Not Used

### 1.3 EXECUTION

#### A. Grinding: This covers grinding asphalt concrete or portland cement concrete pavement and roadway surfaces of structures as shown on the plans and as specified in these specifications and the special provisions

1. Grinding shall be performed with abrasive grinding equipment utilizing diamond cutting blades.
2. Existing portland cement concrete pavement not constructed as part of the project shall be ground as follows:
  - a. Grinding shall be performed so that the pavement surface on both sides of all transverse joints and cracks has essentially the same depth of texture and does not vary from a true plane enough to permit a 1.9 mm thick shim 75 mm wide to pass under a one-meter straightedge adjacent to either side of the joint or crack when the straightedge is laid on the pavement parallel to centerline with its midpoint at the joint or crack. After grinding has been completed, the pavement shall conform to the straightedge and profile requirements specified in paving specification, paragraph "Final Finishing," except that pavement on tangent alignment and on horizontal curves of any radius shall have a profile index of 19 mm or less per 0.1-km.
  - b. Abnormally depressed areas due to subsidence or other localized causes will be excluded from testing with the profilograph and 3.6-m±0.06-m straightedge. The accumulated total of the excluded areas shall not exceed 5 percent of the total area to be ground. Profilograph testing shall end 8 m prior to excluded areas and shall resume 8 m following the excluded areas.
3. Existing asphalt concrete pavement not constructed as part of the project shall be ground so that the finished surface shall not vary from a true plane enough to permit a 3-mm thick shim 75 mm wide to pass under a straightedge 3.6 m±0.06-m long when the straightedge is laid on the finished surface parallel with the centerline. The transverse slope of the finished surface shall be uniform to a degree such that a 6 mm thick shim 75 mm wide will not pass under a straightedge 3.6 m±0.06-m long when the straightedge is laid on the finished surface in a direction transverse to the centerline and extending from edge to edge of a 3.6-m traffic lane.
4. Ground areas on structures, approach slabs and the adjacent 15 m of approach pavement shall conform to the provisions for smoothness and concrete cover over reinforcing steel.
5. Ground surfaces shall not be smooth or polished and, except as otherwise specified, shall have a coefficient of friction of not less than 0.30.
6. Residue from grinding operations shall be picked up by means of a vacuum attachment to the grinding machine and shall not be allowed to flow across the pavement nor be left on the surface of the pavement. Residue from grinding portland cement concrete pavement shall be disposed of





as directed. Residue from grinding asphalt concrete shall be disposed of outside the highway right of way.

7. At the option of the Contractor, the residue from grinding portland cement concrete pavement may be disposed of as directed by the authorities having jurisdiction over the site. A copy of the approval shall be delivered to the Engineer before disposing of residue at the site.
8. The noise level created by the combined grinding operation shall not exceed 86 dBA at a distance of 15 m at right angles to the direction of travel.

B. Grooving: This work shall consist of grooving the surface of asphalt concrete or Portland cement concrete pavement and bridge decks as shown on the plans and as specified in these specifications and the special provisions

1. Grooved areas shall begin and end at lines normal to the pavement center line and shall be centered within the lane width. If new concrete pavement is grooved, the grooving in any lane shall cover the full lane width.
2. Grooving blades shall be 2.41 mm  $\pm$  0.13-mm wide and shall be spaced 19 mm on centers. The grooves shall be cut not less than 3 mm nor more than 7 mm deep. The grooves on bridge decks shall be cut not less than 3 mm nor more than 5 mm deep. Grooves over inductive loop detectors shall be cut not less than 2 mm nor more than 3 mm deep.
3. At the beginning of each work shift, all grooving machines shall be equipped with a full complement of grooving blades that are capable of cutting grooves of the specified width, depth and spacing.
4. If during the course of work a single grooving blade on any individual grooving machine becomes incapable of cutting a groove, work will be permitted to continue for the remainder of the work shift, and the Contractor will not be required to otherwise cut the groove omitted because of the failed blade. Should 2 or more grooving blades on any individual grooving machine become incapable of cutting grooves the Contractor shall either:
  - a. Discontinue work with the affected grooving machine within 15 m of the location where more than one blade became incapable, in which event the Contractor will not be required to otherwise cut the grooves omitted because of the failed blades; **OR**  
Continue work with the affected grooving machine for the remainder of the work shift and by other means cut all grooves omitted, including grooves omitted because a single blade was incapable, by the affected grooving machine within that work shift. The omitted grooves shall be cut before any of the grooving work performed during the time the grooves were omitted will be accepted.
5. The actual grooved area of any selected 0.6-m by 30 m longitudinal area of pavement specified to be grooved shall be not less than 95 percent of the selected area. Grooves which are omitted as permitted for blades which become incapable will be measured as being actually grooved. No area will be measured until omitted grooves, which are required to be cut before the area is accepted, have been cut. Except as provided for omitted grooves due to an incapable blade, any area within the selected area not grooved shall be due only to irregularities in the pavement surface and for no other reason.
6. Residue from grooving operations shall be picked up by means of a vacuum attachment to the grooving machine and shall not be allowed to flow across the pavement nor be left on the surface of the pavement. Residue from grooving portland cement concrete pavement shall be disposed of as directed. Residue from grooving asphalt concrete shall be disposed of outside the highway right of way.
7. At the option of the Contractor, the residue from grooving portland cement concrete pavement may be disposed as directed by the authorities having jurisdiction over the site. A copy of the approval shall be delivered to the Engineer before disposing of residue at the site.
8. The noise level created by the combined grooving operation shall not exceed 86 dBA at a distance of 15 m at right angles to the direction of travel.

C. Highway or Street Grooving: AASHTO recommends the following groove specifications: 2.4 mm wide; depth of 3.2 to 4.8 mm, and a center-to-center spacing of 19.1 mm (0.75 inches) (7). The center 10-foot portion of a 12-foot lane is typically grooved, leaving a 1-foot strip ungrooved at the edge of each lane.

- D. Boat Ramp Grooving: Grooves shall be non-skid V-grooves spaced 2 inches on center, 1/2-inch radius, 1/2-inch deep.
- E. Runway Grooving
1. General
    - a. The grooving dimensions shall be as follows:
      - 1) Depth - One-quarter (1/4) inch  $\pm$  one sixteenth (1/16) inch
      - 2) Width - One-quarter (1/4) inch  $\pm$  one sixteenth (1/16) inch
      - 3) Center to center - One and one-half (1 1/2) inch  $\pm$  one eighth (1/8) inch
    - b. Grooving shall not begin until new pavement has properly cooled/cured and permission is given.
    - c. In no case shall final painted pavement markings be applied prior to grooving.
  2. The pavement must be grooved by approved diamond bladed saw-cutting equipment. Variations in the grooving contour will not be permitted without approval. All reasonable precautions shall be taken to avoid breaking or chipping the pavement surfaces between grooves. Excessive spalling of the grooved edges will not be permitted.
  3. The Contractor shall groove bituminous concrete and portland cement concrete pavements according to the following specifications (from FAA Advisory Circular 150/5320-12B, Section IV):
    - a. The depth of 90 percent or more of the groove shall not be less than 1/4 inch.
    - b. The grooves shall be continuous for the entire runway length and transverse (perpendicular) to the direction of aircraft landing and takeoff operations.
    - c. The grooves shall be continued to the end of the runway where the concrete meets the asphalt.
    - d. The grooves shall not vary more than 3 inches in alignment for 75 feet, allowing for realignment every 500 feet.
    - e. Grooves shall not be closer than 3 inches or more than 9 inches from transverse joints in concrete pavements.
    - f. Grooving through longitudinal or diagonal saw kerfs where lighting cables are installed shall be avoided. Grooves may be continued through longitudinal construction joints.
    - g. Grooves shall be sawed no closer than 6 inches and no more than 18 inches from in-pavement light fixtures.
  4. Cleanup is extremely important and should be continuous throughout the grooving operations. Accumulation of debris resulting from the grooving operations shall be cleaned from the grooves and removed from the pavement by air jets, high pressure water streams, or other approved methods, after each grooving operation at hourly intervals. The Contractor shall provide water for cleanup operations. The waste material shall not be flushed into the storm or sanitary sewer system. The waste material shall not be allowed to drain onto the shoulders or left on the runway surface in order to prevent foreign object damage.

END OF SECTION 32 01 16 71

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## SECTION 32 01 16 74 - BITUMINOUS REJUVENATION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of bituminous rejuvenation of airfield pavements, roads, streets, parking areas, and other general applications by the use of a chemical rejuvenator. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

- #### A. Rejuvenator: The asphalt rejuvenating agent shall be composed of a petroleum resin-oil base uniformly emulsified with water and shall conform to the following physical and chemical requirements:

#### B. Property Test Method Requirement

Viscosity, S.F. at 77 F, sec.	ASTM D 244	15-40
Residue, % (1)	ASTM D 244 (Mod.)	60-65(min.)
Sieve Test, %	ASTM D 244 (Mod.)	0.10 (max.)
Viscosity @ 140 F, centistokes (2)	ASTM D 2170	80-500
Flash Point, Cleveland Open Cup(COC), °F (3)	ASTM D 92	350 (min.)

(1) ASTM D 244 Modified Evaporation Test for percent residue is made by heating 50 gm samples to 300°F until foaming ceases; then cool immediately and calculate results.

(2) Viscosity on residue obtained from evaporation test.

(3) Flash point on residue from evaporation test.

- #### C. Aggregate: Gradation of mineral aggregate shall meet the following requirements:

Sieve Percent by Designation	Weight Passing
No. 16	100
No. 30	40-75
No. 50	4-12
No. 100	0-5

### 1.3 EXECUTION

- #### A. Bituminous Storage Tanks shall be capable of heating the bituminous material under effective and positive control at all times to the required temperature.
- #### B. Bituminous Distributor shall be designed and equipped to spray the bituminous material in a uniform double to triple lap at the temperature recommended by the manufacturer, at variable widths, and at readily determined and controlled rates from 0.04 to 0.2 gallons per square yard, plus or minus 5 percent.
- #### C. Brooms and Blowers shall be of the power type.
- #### D. Preparation of Surface: Immediately before applying the rejuvenator, all loose material, dirt, clay, or other objectionable material shall be removed from the surface to be treated.



- E. Application of Rejuvenator: The rejuvenator shall be uniformly applied over the surface at the approved rate with an allowable variation of plus or minus 20 percent. Materials shall be applied at the temperature recommended by the manufacturer.
- F. Excess Rejuvenator Material: Approved mineral aggregate shall be provided by the Contractor and shall be spread in sufficient quantity to effectively blot up any excess rejuvenator material remaining on the treated pavement surface after 24 hours.
- G. Insufficient Rejuvenator Material: When it is determined by the Owner that the actual application rate of the rejuvenator is more than 20 percent below the approved application rate, subsequent application(s) shall be made within 24 hours to ensure adequate penetration into the pavement surface.

END OF SECTION 32 01 16 74

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## SECTION 32 01 16 74a - COLD MIX RECYCLING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of cold mix recycling of existing paving and the addition of new materials. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Aggregates:

1. General: Aggregates shall consist of material obtained from milling, or removing and crushing the existing in situ material, and/or new aggregate material as needed.
2. Aggregate Quality and Gradation: Aggregate for bituminous mixture shall be of such size that the material can be spread with a paver to the desired thickness and compacted to meet the specified smoothness, grade, and density requirements. New aggregates shall be approved and be equal to or better than the reclaimed aggregate in quality. Maximum size of new aggregate shall not exceed one-half of the layer thickness and in no case shall the maximum aggregate size exceed 1 inch.

- #### B. Bituminous Materials:
- Bituminous materials, if required, shall be an emulsified asphalt conforming to ASTM D 977 or ASTM D 2397, grade as required.

- #### C. Job-Mix Formula:
- The Job-Mix Formula (JMF) for the recycled mixture will be furnished by the Contractor to the Owner. The formula will indicate a definite percentage of water and asphalt to be added to the mixture. The JMF will be allowed an asphalt content tolerance of 0.3 percent. The asphalt content may be adjusted by the Owner to improve paving mixture, without adjustment in contract unit price. When asphalt is added, the optimum asphalt content will be selected to provide the following properties when samples are compacted at 250 F with 75 blows of standard Marshall hammer on each side of the specimen.

##### Property Requirement

Stability minimum, pounds	1,800
Flow maximum, 1/100-inch units	16
Voids in total mix, percent	3-5
Voids filled with bitumen, percent	70-80

The water content will be selected to provide maximum density when samples are prepared at the optimum asphalt content and compacted with 75 blows of Marshall hammer at ambient temperature. When no asphalt binder is added to the mixture, the water content will be selected by the Owner to provide maximum density.

### 1.3 EXECUTION

- #### A. Preparation of Bituminous Mixtures:
- The required amount of bituminous material for each batch, or calibrated amount of continuous mixing, shall be introduced into the mixer. Aggregates, asphalt emulsion, and water shall be mixed for 35 seconds or longer, as necessary, to thoroughly coat all

particles with bituminous material. When longer mixing time is necessary, additional mixing time shall be determined by the Owner.

- B. Conditioning of Existing Surface: Ruts or soft yielding spots that appear in the existing pavement areas and deviations of surface from requirements specified shall be corrected. An asphalt tack coat shall be applied to all contact surfaces in advance of the recycled overlayment. The asphalt tack shall be placed at an asphalt residue coverage rate of 0.05 gal/sq. yd.
- C. Placing:
1. Layer Thickness and Curing: Each layer of compacted mixture shall be no more than 2-1/2 inches in thickness; each layer of bituminous mixture shall be allowed to cure for at least 5 days before placing a succeeding layer.
  2. Compaction of Mixture: Bituminous mixtures shall be rolled until all roller marks are eliminated and a density of at least 86 percent of the theoretical maximum density has been obtained when tested in accordance with MIL-STD-620, Method 101 or ASTM D 2041. When bituminous material is not added to the cold recycled mixture, the material shall be compacted to 100 percent of density determined by MIL-STD-621, Method 100, compaction effort designation CE-55.
  3. Joints: Longitudinal joints shall be offset at least 1 foot from existing joints. Transverse joints shall be offset at least 2 feet from existing transverse joints.
  4. Surface Smoothness: After final rolling, the pavement surface shall not vary in excess of 1/8 inch from a straightedge laid on the surface.

END OF SECTION 32 01 16 74a

## SECTION 32 01 16 74b - CENTRAL PLANT HOT-MIX RECYCLING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of central plant hot-mix recycling of existing asphalt concrete intermediate and wearing courses for airfields, heliports, and heavy-duty pavements. The specification also includes the addition of new materials, as required to meet project requirements. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Aggregates:

1. General: Aggregates shall consist of material obtained from milling, or removing and crushing the existing in-situ material, and/or new aggregate material as needed.
2. Aggregate Quality and Gradation: Aggregate for the bituminous mixture shall be such size that the material can be spread with a paver to the desired thickness and compacted to meet the specified smoothness, grade, and density requirements. New aggregates shall be approved and shall be equal to or better than the reclaimed aggregate in quality. Maximum size of new aggregate shall not exceed one-half of the layer thickness, and in no case shall the maximum aggregate size exceed one inch. Aggregate gradations shall be as prescribed by local usage, with the approval of the Owner. In order to meet pollution requirements and ensure the recycled mixture is satisfactory, the amount of reclaimed asphalt pavement shall not exceed 60 percent for drum mixers or 50 percent for batch plants.

#### B. Mineral Filler shall conform to ASTM D 242.

#### C. Bituminous Materials:

1. New Asphalt Cement: The appropriate types and grades of bituminous materials for the anticipated use and climactic environment shall be used. Requirements of ASTM D 946 shall be used to specify penetration-graded asphalt cement, or ASTM D 3381 for viscosity-graded asphalt cement.
2. Recycled Asphalt Cement: The penetration of asphalt cement recovered from the recycled mixture shall be in accordance with ASTM D 1856 and shall have a penetration between 50 and 70 percent of that specified for the particular region for new asphalt cement, measured in accordance with ASTM D 5.

#### D. Job-Mix Formula (JMF): The JMF for the recycled mixture will be furnished by the Contractor to the Owner. The formula will indicate the percentage of reclaimed asphalt pavement, the percentage of bitumen, and the temperature of the completed mixture when discharged from the mixer. The requirements for stability, flow, and voids are shown in the following tables for nonabsorptive and absorptive mixtures, respectively.

##### 1. Nonabsorptive-Aggregate Mixture

	Wearing Property Course	Intermediate Course
Stability minimum, lbs	1,800	1,800
Flow maximum, 1/100-inch units	16	16



	Voids total mix, percent	3-5	5-7
	Voids filled with bitumen, percent	70-80	50-70
2.	Absorptive-Aggregate Mixture		
		Wearing	Intermediate
		Property Course	Course
	Stability minimum, lbs.	1,800	1,800
	Flow maximum, 1/100-inch units	16	16
	Voids total mix, percent	2-4	4-6
	Voids filled with bitumen, percent	75-80	55-75

When the water-absorption value of the entire blend of aggregate does not exceed 2.5 percent, the aggregate is designated as nonabsorptive. When the water-absorption value exceeds 2.5 percent as determined by ASTM C 127 and ASTM C 128, the aggregate is designated as absorptive.

### 1.3 EXECUTION

- A. Preparation of Bituminous Mixtures: Aggregates, reclaimed asphalt pavement, mineral filler, bitumen, and recycling agent shall be conveyed into the mixer in proportionate quantities required to meet the JMF. Particles larger than 2 inches shall be removed from the reclaimed asphalt pavement prior to being added to the mixer. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material. Temperature of bitumen at time of mixing will be as required to meet project requirements. Temperature of aggregate and mineral filler in the mixer shall not exceed 325 F when bitumen is added.
- B. Surface Preparation of Underlying Course: Prior to placing of intermediate or wearing course, the underlying course shall be cleaned of all foreign or objectionable matter. The surface of previously constructed base course shall be sprayed with a prime coat at an asphalt residue coverage rate of 0.25 gal/sq. yd. Contact surfaces of previously constructed pavement, curbs, manholes, and other structures shall be sprayed with a thin tack coat at an asphalt residue coverage rate of 0.05 gal/sq. yd.
- C. Placing:
  1. Layer Thickness and Curing: A required uncompacted thickness of intermediate course, 7 inches or less, may be spread and compacted in one layer. Where the required thickness of base is more than 7 inches, the mixture shall be spread and compacted in two or more layers. Each layer of compacted mixture for the surface course shall be no more than 2-1/2 inches in thickness. Each layer of bituminous mixture shall be allowed to cure for at least 5 days before placing a succeeding layer.
  2. Compaction of Mixture: Rolling shall begin as soon after placing as the mixture will bear roller without undue displacement. After the Contractor is assured of meeting crown, grade, and smoothness requirements, rolling shall be continued until a mat density of 98 to 100.0 percent and a joint density of 96.5 to 100.0 percent of density is obtained. Places inaccessible to rollers shall be thoroughly compacted with hot hand tampers.
  3. Joints: Longitudinal joints shall be offset at least 1 foot from existing joints. Transverse joints shall be offset at least 2 feet from existing transverse joints.
  4. Surface Smoothness: After final rolling, the pavement surface shall not vary in excess of 1/8 inch from a straightedge laid on the surface.

END OF SECTION 32 01 16 74b

Task	Specification	Specification Description
32 01 16 74	32 01 13 61	Asphalt Paving
32 01 17 61	32 01 13 61	Asphalt Paving
32 01 17 61	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 01 17 61	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 01 26 71	32 01 16 71	Grinding/Grooving Pavement
32 01 90 13	31 13 13 00	Tree Protection And Trimming
32 01 90 19	01 22 16 00	No Specification Required
32 01 90 23	31 13 13 00	Tree Protection And Trimming
32 01 90 26	31 13 13 00	Tree Protection And Trimming
32 01 90 36	31 13 13 00	Tree Protection And Trimming
32 01 90 36	31 31 19 13	Soil Sterilization
32 01 90 39	31 13 13 00	Tree Protection And Trimming
32 01 90 43	31 13 13 00	Tree Protection And Trimming
32 01 90 46	31 13 13 00	Tree Protection And Trimming
32 01 90 53	31 13 13 00	Tree Protection And Trimming

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## SECTION 32 11 16 16 - CRUSHED STONE PAVING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of crushed stone paving. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

### 1.2 PRODUCTS

- A. Aggregates: Aggregates shall consist of crushed stone or slag, crushed gravel, angular sand, or other approved materials. Aggregates shall be durable, sound, and free from foreign material.
1. Coarse Aggregates, consisting of angular fragments of uniform density and quality, shall have a percentage of wear not to exceed 50 percent after 500 revolutions when tested in accordance with ASTM C131. The amount of flat and elongated particles (length to width greater than 3 to 1) shall not exceed 30 percent.
  2. Crushed Gravel shall be manufactured from gravel particles with the following gradation:

100% passing	2" sieve
25 - 60% passing	1/4" sieve
5 - 40% passing	#40 sieve
0 - 10%	#200 sieve
  3. Crushed Stone shall contain at least 50 percent by weight of crushed pieces having two or more freshly fractured faces for each range of sizes.
  4. Slag shall be an air-cooled blast-furnace product having a dry weight of not less than 65 pcf.
- B. Binder Material shall consist of screenings, angular sand, or other finely divided mineral matter processed or naturally combined with the coarse aggregate.

### 1.3 EXECUTION

#### A. Installation:

1. Mixing and Placing: Materials shall be mixed in such a manner as to obtain a uniform stabilized-aggregate material and a uniform optimum water content for compaction. Mixing and placing procedures shall produce true grades, minimize segregation and degradation, optimize water content, and ensure a satisfactory base course.
2. Compaction: Each layer of stabilized-aggregate paving shall be compacted. Water content shall be maintained at optimum. Areas inaccessible to the rollers shall be compacted, with mechanical tampers and shall be shaped and finished by hand methods.
3. Layer Thickness: No layer shall be in excess of 8 inches nor less than 3 inches in compacted thickness.
4. Proof Rolling: Materials in paving or underlying materials that produce unsatisfactory results by rolling shall be removed and replaced with satisfactory materials and recompact.
5. Edges of Paving: Approved materials shall be placed along edges of stabilized-aggregate paving course in such quantities as will compact to thickness of the course being constructed, allowing at least a 1-foot width of the shoulder to be rolled and compacted simultaneously with rolling and compacting of each layer of the paving course.
6. Finishing: Finished surface shall be of uniform grade and texture.
7. Thickness Control: Compacted thickness of the stabilized paving course shall be within 1/2 inch of the thickness required.

END OF SECTION 32 11 16 16

NOT FOR BID

## SECTION 32 11 16 16a - CRUSHED STONE

### 1.1 GENERAL

#### A. Description Of Work

- The work under this section consists of furnishing, placing and compacting crushed stone where called for and as detailed, in conformance with lines, grades and typical as follows or as directed by the Owner.

### 1.2 PRODUCTS

#### A. Materials

- Material shall consist of clean, coating free, durable, sharp angled fragments of crushed stone, crushed ledge rock, or blends thereof that conform to the specific requirements of the following table. Shale will not be acceptable.
- Crushed Stone used in Absorption Beds shall be washed and free of fines.
- Gradation: Crushed stone sizes shall meet the gradation requirements of Table 1-1.

TABLE 1-1 (1) GRADATION OF CRUSHED STONE

Size Designation	4"	3"	2-1/2"	2"	1-1/2"	1"	1/2"	1/4"	1/8"	No.80 Sieve
Screening (2)							100	90-100		
1B								100	90-100	0-15
1A							100	90-100	0-15	
1 <sup>st</sup>							100	0-15		
1						100	90-100	0-15		
2					100	90-100	0-15			
3A				100	90-100	0-15				
3			100	90-100	5-70	0-15				
4A		100	90-100		0-20					
4	100	90-100		0-15						
5	90-100	0-15								

- Percentage by weight passing the following square openings.
  - Screenings shall include all of the fine material passing a 1/4-inch screen.
- All crushing plants shall be fitted with tailing chutes so that no aggregate will reach the bins other than that which passes through the proper screens

- #### B. Soundness:
- Material furnished under this item shall be substantially free of shale or other soft, poor durability particles. A visual inspection of particle composition by the Owner will generally be the basis



for acceptance. Where the State elects to test for this requirement, a Magnesium Sulfate Soundness Loss exceeding 35 percent will be cause for rejection.

- C. Contamination: Contamination of the crushed stone with any deleterious material, such as silt, clay, mud, ice, snow or organic materials, through any cause whatsoever, shall be corrected by the Contractor by excavation and replacement of the material in the affected areas.
- D. Sampling: Samples and certified gradations shall be furnished by the Contractor to the Owner and approval of these samples must be received prior to delivery or placement of the material.

### 1.3 EXECUTION

- A. Compaction: All material shall be placed in uniform horizontal layers not exceeding 6-inches thickness before compaction. All portions of each layer shall be mechanically compacted to the satisfaction of the Owner. Compaction equipment shall be approved by the Owner.

END OF SECTION 32 11 16 16a

## SECTION 32 11 16 16b - SELECT GRAVEL

### 1.1 GENERAL

#### A. Description Of Work

1. The work under this section consists of furnishing, placing and compacting select gravel where called for and as detailed, in conformance with lines, grades and typical sections as provided or directed by the Owner.

### 1.2 PRODUCTS

#### A. Materials

1. Material shall consist of clean, durable gravel or crushed stone free from coating.
2. Select Gravel used for stone paving shall be manufactured from crushed stone and contain no gravel.
3. Gradation of gravel or stone shall be as follows with percent passing calculated by weight:

Select Gravel	
Sieve	Percent Passing
2"	100
1/4"	30 - 65
No. 40	5 - 40
No. 200	0 - 10

### 1.3 EXECUTION

- A. Soundness: Materials furnished under this item shall be substantially free of shale, organic or other soft, poor durability particles. A visual inspection of particle composition by the Owner will generally be the basis for acceptance. Where the Owner elects to test for this requirement, a Magnesium Sulfate Soundness Loss exceeding 35 percent will be cause for rejection.
- B. Contamination: Contamination of the Select Gravel with any deleterious material, such as silt, clay, mud, ice, snow or organic material, through any cause whatsoever, shall be corrected by the Contractor by excavation and replacement of the material in the affected area.
- C. Sampling: Samples and certified gradations shall be furnished by the Contractor to the Owner and approval of these samples must be received prior to delivery or placement of the material.
- D. Compaction:
  1. All material shall be placed in uniform horizontal layers not exceeding 6-inches thickness before compaction. All portions of each layer shall be mechanically compacted to the percentage of the Standard Proctor Maximum Density (AASHTO T-99) as follows, unless noted otherwise. Compaction equipment approval shall be made by the Owner.
  2. Density determination.
    - a. Structures (entire area within 10 feet outside perimeter) 95%
    - b. Building Slabs and Steps: 95%
    - c. Lawn or Unpaved Areas: 90%
    - d. Pavements and Walkways: 95%
    - e. Pipes and Tunnels: 95%
    - f. Pipe Bedding: 100%





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END OF SECTION 32 11 16 16b

NOT FOR BID



Task	Specification	Specification Description
32 11 23 16	32 11 16 16	Crushed Stone Paving
32 11 23 16	32 11 16 16a	Crushed Stone
32 11 23 16	32 11 16 16b	Select Gravel

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## SECTION 32 12 13 13 - BITUMINOUS PAVING-REPAIR AND RESURFACING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials repair and resurfacing of bituminous pavements. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Reports: Copies of test results, within 24 hours after completion of tests.
2. Waybills and Delivery Tickets: Copies of waybills or delivery tickets, during the progress of the work.

### 1.2 PRODUCTS:

#### A. Asphaltic Concrete:

1. Hot-Mixed, Hot-Mixed Asphaltic Concrete and Emulsified asphalt shall comply with requirements of ASTM D 3515.
2. Plant-Mixed, Stockpiled Asphalt Cold Mixes shall comply with the requirements of Asphalt Institute Specification PM-2.

#### B. Bituminous Prime: Bituminous primer shall comply with ASTM D 2027.

#### C. Base Course: Base course material shall comply with State highway department specification for dense-graded, high-quality material.

#### D. Bituminous Tack Coat: Bituminous tack coat shall comply with ASTM D 2027.

### 1.3 EXECUTION:

#### A. Preparation of Areas for Patching:

1. Pot Holes: Trim the perimeter of each hole to a vertical face with a carborundum blade in a square or rectangular pattern at least 18 inches from ragged edge. Remove material to a depth that provides a uniform well-compacted bottom surface. Remove all loose material resulting from trimming or otherwise existing in the hole. If subbase is disturbed, reestablish in a like manner to adjacent substrate. Areas to be repaired shall be dry before repair is started.
2. Alligator-Cracked and Rutted Areas: The pavement shall be sawed or cut with pavement breakers to a smooth vertical face 18 inches outside of the alligator-cracked area. Unsatisfactory material shall be removed in a manner not to disturb the sides of the excavated area.
3. Slippage Areas: Saw a rectangular area around the slippage area that overlaps into the well-bonded material by at least 18 inches. The depth of the saw cut shall be equal to the thickness of the layer of material that is slipping. The surface where slipping is occurring shall be broomed clean and all loose material removed.

#### B. Installation:

1. Application Temperatures: Application temperatures for all asphalt material shall comply with provisions of the Asphalt Institute Publications and the applicable ASTM Standards.

2. Base Course: Place base course material in layers not exceeding a compacted thickness of 6 inches. After placing, compact each layer by mechanical compactors to a density of not less than the density of the corresponding layer of the adjacent pavement structure.
3. Prime Coat: Prime base course with MC-70 liquid asphalt at a rate of 0.20 to 0.30 gallon per sq. yd. Bolt excess prime with sand before the surfacing material is applied.
4. Tack Coat: Give the edges of existing asphaltic concrete or surfaces of Portland cement concrete and asphaltic concrete a tack coat of MC-70 liquid asphalt at a rate of 0.05 to 0.15 gallon per sq. yd. Allow the material to cure before placing the surfacing material.
5. Hot-Mixed Asphaltic Concrete: Place the material in layers not exceeding 2-1/2 inches in thickness and compact to a density equal to the density of the adjacent asphaltic concrete.
6. Stockpiled Cold Mixes: The compacted thickness of each layer of material shall not exceed 2 inches. Before compaction, the material shall be allowed to aerate, if necessary, until the proper amount of cohesion has developed to obtain adequate compaction. When more than one layer is used, each layer shall be thoroughly cured before the succeeding layer is placed.

END OF SECTION 32 12 13 13

## SECTION 32 12 13 13a - ASPHALTIC CONCRETE OVERLAYS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of asphaltic concrete overlays. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

- A. Asphalt Cement: The asphalt cement shall comply with ASTM D 946 penetration grade 85-100 requirements and shall show a negative spot test when tested in compliance with AASHTO T 102.

- B. Mineral Aggregates: Shall comply with ASTM D 3515 for 3/4-inch maximum aggregate mix.

- C. Test Properties: The bituminous mixture shall meet the following requirements when tested in compliance with MIL-STD 620.

Stability minimum, lb	500
Flow maximum, 1/100-in. units	20
Voids total mix, %	3-5
Voids filled with bitumen, %	75-85

### 1.3 EXECUTION

- A. Preparation of Existing Surface: The Contractor shall raise and reset all structures such as manhole frames, valve boxes, drainage structures, etc., to meet the required grade. An asphalt tack coat shall be applied to all contact surfaces in advance of the asphalt concrete overlay placement. The asphalt tack shall be placed at an asphalt residue coverage rate of 0.05 gal/sq yd.

#### B. Installation:

1. Joints: Longitudinal joints of the overlay shall be offset at least 1 foot from existing joints. Transverse joints shall be offset at least 2 feet from existing transverse joints.
2. All Asphalt Concrete Mixture and Pavement that are contaminated, damaged, or defective shall be removed and replaced by the Contractor. Skin patching of rolled pavement will not be permitted.
3. Compaction of Mixture: The asphalt concrete mixture shall be rolled until a density of not less than 95 percent and not more than 100 percent of laboratory compacted specimen is obtained.
4. Surface Smoothness: After final rolling, the pavement surface shall not vary in excess of 1/8 inch from a 10-foot straightedge laid on the surface.

END OF SECTION 32 12 13 13a

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Task	Specification	Specification Description
32 12 13 13	32 01 13 61	Asphalt Paving
32 12 13 19	32 01 13 61	Asphalt Paving
32 12 13 19	32 12 13 13	Bituminous Paving-Repair And Resurfacing
32 12 13 19	32 12 13 13a	Asphaltic Concrete Overlays
32 12 16 13	32 01 13 61	Asphalt Paving
32 12 16 13	32 12 13 13	Bituminous Paving-Repair And Resurfacing
32 12 16 13	32 12 13 13a	Asphaltic Concrete Overlays
32 12 16 19	32 12 13 13	Bituminous Paving-Repair And Resurfacing
32 12 16 19	32 12 13 13a	Asphaltic Concrete Overlays
32 12 16 39	31 32 13 16	Soil Stabilization-Lime
32 12 16 39	31 25 14 13	Geosynthetic Fabric
32 12 16 43	32 01 13 61	Asphalt Paving
32 12 16 43	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 12 16 43	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 12 33 00	32 01 13 61	Asphalt Paving
32 12 33 00	32 12 13 13	Bituminous Paving-Repair And Resurfacing
32 12 33 00	32 12 13 13a	Asphaltic Concrete Overlays
32 12 36 13	32 01 13 61	Asphalt Paving
32 12 36 13	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 12 36 16	32 01 13 61	Asphalt Paving
32 12 36 16	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 12 36 16	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 12 36 23	32 01 13 61	Asphalt Paving
32 12 36 23	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 12 36 23	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments



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## SECTION 32 13 13 33 - DECORATIVE CEMENT CONCRETE PAVEMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for decorative cement concrete pavement. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section includes colored, stamped, stenciled, and stained concrete paving.

#### C. Definitions

1. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. LEED Submittals:
  - a. Product Data for Credit MR 4.1 and Credit MR 4.2, **as directed**: For products having recycled content, documentation indicating percentages by weight of postconsumer and preconsumer recycled content. Include statement indicating costs for each product having recycled content.
  - b. Design Mixtures for Credit ID 1.1: For each concrete mixture containing fly ash as a replacement for portland cement or other portland cement replacements. For each design mixture submitted, include an equivalent concrete mixture that does not contain portland cement replacements, to determine amount of portland cement replaced.
3. Samples: For each type of exposed color, pattern, or texture indicated.
4. Other Action Submittals:
  - a. Design Mixtures: For each decorative concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
5. Qualification Data: For qualified Installer, ready-mix concrete manufacturer, and testing agency.
6. Material Certificates: For the following, from manufacturer:
  - a. Cementitious materials.
  - b. Steel reinforcement and reinforcement accessories.
  - c. Fiber reinforcement.
  - d. Admixtures.
  - e. Curing compounds.
  - f. Applied finish materials.
  - g. Bonding agent or epoxy adhesive.
  - h. Joint fillers.
7. Material Test Reports: For each of the following:
  - a. Aggregates. Include service-record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
8. Field quality-control reports.

#### E. Quality Assurance

1. Installer Qualifications: An employer of workers trained and approved by manufacturer of decorative concrete paving systems.
2. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

- a. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities" (Quality Control Manual - Section 3, "Plant Certification Checklist").
3. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.
  - a. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-1 or an equivalent certification program.
4. Source Limitations: Obtain decorative concrete paving products and each type or class of cementitious material of the same brand from same manufacturer's plant, and obtain each aggregate from single source.
5. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.
6. ACI Publications: Comply with **ACI 301 (ACI 301M)** unless otherwise indicated.
7. Preinstallation Conference: Conduct conference at Project site.

F. Project Conditions

1. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

## 1.2 PRODUCTS

A. Forms

1. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.
  - a. Use flexible or uniformly curved forms for curves of a radius of **100 feet (30.5 m)** or less. Do not use notched and bent forms.
2. Forms for Textured Finish Concrete: Units of face design, size, arrangement, and configuration indicated. Provide solid backing and form supports to ensure stability of textured form liners.
3. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

B. Steel Reinforcement

1. Recycled Content: Provide steel reinforcement with an average recycled content of steel so postconsumer recycled content plus one-half of preconsumer recycled content is not less than 25 percent.
2. Plain-Steel Welded Wire Reinforcement: ASTM A 1064/A 1064M, fabricated from as-drawn steel wire into flat sheets.
3. Reinforcing Bars: ASTM A 615/A 615M, **Grade 60 (Grade 420)**; deformed.
4. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, **Grade 60 (Grade 420)**, deformed bars; assembled with clips.
5. Plain-Steel Wire: ASTM A 82/A 82M, as drawn.
6. Joint Dowel Bars: ASTM A 615/A 615M, **Grade 60 (Grade 420)** plain-steel bars. Cut bars true to length with ends square and free of burrs.
7. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:
  - a. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

C. Concrete Materials

1. Cementitious Material: Use the following cementitious materials, of the same type, brand, and source, throughout Project:

- a. Portland Cement: ASTM C 150, gray **OR** white, **as directed**, portland cement Type I **OR** Type II **OR** Type I/II **OR** Type III **OR** Type V, **as directed**. Supplement with the following, **as directed**:
    - 1) Fly Ash: ASTM C 618, Class C or F.
    - 2) Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.
  - b. Blended Hydraulic Cement: ASTM C 595, Type IS, portland blast-furnace slag **OR** Type IP, portland-pozzolan, **as directed**, cement.
  2. Normal-Weight Aggregates: ASTM C 33, Class 4S **OR** Class 4M **OR** Class 1N, **as directed**, uniformly graded. Provide aggregates from a single source with documented service-record data of at least 10 years' satisfactory service in similar paving applications and service conditions using similar aggregates and cementitious materials, **as directed**.
    - a. Maximum Aggregate Size: **1-1/2 inches (38 mm) OR 1 inch (25 mm) OR 3/4 inch (19 mm)**, **as directed**, nominal.
    - b. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.
  3. Water: Potable and complying with ASTM C 94/C 94M.
  4. Air-Entraining Admixture: ASTM C 260.
  5. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
    - a. Water-Reducing Admixture: ASTM C 494/C 494M, Type A, colored, **as directed**.
    - b. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D, colored, **as directed**.
    - c. Water-Reducing and Accelerating Admixture: ASTM C 494/C 494M, Type E.
  6. Color Pigment: ASTM C 979, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, free of carbon black, **as directed**, nonfading, and resistant to lime and other alkalis.
- D. Fiber Reinforcement
1. Synthetic Fiber: Monofilament or fibrillated polypropylene fibers engineered and designed for use in decorative concrete paving, complying with ASTM C 1116/C 1116M, Type III, **1/2 to 1-1/2 inches (13 to 38 mm)** long.
- E. Surface Coloring Materials
1. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.
  2. Pigmented Powder Release Agent: Factory-packaged, dry combination of surface-conditioning and dispersing agents interground with color pigments that facilitates release of stamp mats. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.
  3. Liquid Release Agent: Manufacturer's standard, clear, evaporating formulation that facilitates release of stamp mats and texture rollers.
- F. Stamping Devices
1. Stamp Mats: Semirigid polyurethane mats with projecting textured and ridged underside capable of imprinting texture and joint patterns on plastic concrete.
  2. Stamp Tools: Open-grid, aluminum or rigid-plastic stamp tool capable of imprinting joint patterns on plastic concrete.
  3. Rollers: Manually controlled, water-filled aluminum rollers with projecting ridges on drum capable of imprinting texture and joint patterns on plastic concrete.
  4. Texture Rollers: Manually controlled, abrasion-resistant polyurethane rollers capable of imprinting texture on plastic concrete.
- G. Stencil Materials
1. Stencils: Manufacturer's standard, moisture-resistant paper or reusable plastic stencils, designed for use on plastic concrete.

## H. Stain Materials

1. Reactive Stain: Acidic-based stain with wetting agents and high-grade, UV-stable metallic salts that react with calcium hydroxide in cured concrete to produce permanent, variegated, or translucent color effects.
2. Penetrating Stain: Water-based, acrylic latex, penetrating stain with colorfast pigments.

## I. Curing And Sealing Materials

1. Curing Paper: Nonstaining, waterproof paper, consisting of two layers of kraft paper cemented together and reinforced with fiber, and complying with ASTM C 171.
2. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
3. Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type I, Class B, manufactured for colored concrete.
  - a. For integrally colored concrete, curing compound shall be pigmented type approved by coloring admixture manufacturer.
  - b. For concrete indicated to be sealed, curing compound shall be compatible with sealer.
4. Clear, Solvent-Borne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type I, Class A, manufactured for use with colored concrete.
5. Clear, Waterborne, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type I, Class A, manufactured for use with colored concrete.
6. Clear Acrylic Sealer: Manufacturer's standard, waterborne, nonyellowing and UV-resistant, membrane-forming, medium-gloss, acrylic copolymer emulsion solution, manufactured for colored concrete, containing not less than 15 percent solids by volume.
7. Slip-Resistance-Enhancing Additive: Manufacturer's standard finely graded aggregate or polymer additive, designed to be added to clear acrylic sealer to enhance slip resistance of sealed paving surface.

## J. Related Materials

1. Joint Fillers: ASTM D 1751, asphalt-saturated cellulosic fiber or ASTM D 1752, cork or self-expanding cork in preformed strips.
2. Bonding Agent: ASTM C 1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
3. Epoxy Bonding Adhesive: ASTM C 881/C 881M, two-component epoxy resin capable of humid curing and bonding to damp surfaces; of class suitable for application temperature, of grade complying with requirements, and of the following types:
  - a. Types I and II, non-load bearing **OR** Types IV and V, load bearing, **as directed**, for bonding hardened or freshly mixed concrete to hardened concrete.
4. Polyethylene Film: ASTM D 4397, **1 mil (0.025 mm)** thick, clear.

## K. Concrete Mixtures

1. Prepare design mixtures, proportioned according to **ACI 301 (ACI 301M)**, for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.
  - a. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.
2. Proportion mixtures to provide normal-weight concrete with the following properties:
  - a. Compressive Strength (28 Days): **4500 psi (31 MPa) OR 4000 psi (27.6 MPa) OR 3500 psi (24.1 MPa) OR 3000 psi (20.7 MPa), as directed.**
  - b. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45 **OR** 0.50, **as directed.**
  - c. Slump Limit: **4 inches (100 mm) OR 5 inches (125 mm), as directed**, plus or minus **1 inch (25 mm).**
3. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:
  - a. Air Content: 5-1/2 **OR** 4-1/2 **OR** 2-1/2, **as directed**, percent plus or minus 1.5 percent for **1-1/2-inch (38-mm)** nominal maximum aggregate size.

- b. Air Content: 6 **OR** 4-1/2 **OR** 3, **as directed**, percent plus or minus 1.5 percent for 1-inch (25-mm) nominal maximum aggregate size.
- c. Air Content: 6 **OR** 5 **OR** 3-1/2, **as directed**, percent plus or minus 1.5 percent for 3/4-inch (19-mm) nominal maximum aggregate size.
4. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 **OR** 0.30, **as directed**, percent by weight of cement.
5. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.
  - a. Use water-reducing admixture **OR** water-reducing and retarding admixture **OR** water-reducing and accelerating admixture, **as directed**, in concrete as required for placement and workability.
  - b. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
6. Cementitious Materials: Limit percentage by weight of cementitious materials other than portland cement according to ACI 301 (ACI 301M) requirements for concrete exposed to deicing chemicals **OR** as follows, **as directed**:
  - a. Fly Ash or Pozzolan: 25 percent.
  - b. Ground Granulated Blast-Furnace Slag: 50 percent.
  - c. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.
7. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m).
8. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

L. Concrete Mixing

1. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116/C 1116M, **as directed**. Furnish batch certificates for each batch discharged and used in the Work.
  - a. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
2. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
  - a. For concrete batches of 1 cu. yd. (0.76 cu. m) or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
  - b. For concrete batches larger than 1 cu. yd. (0.76 cu. m), increase mixing time by 15 seconds for each additional 1 cu. yd. (0.76 cu. m).
  - c. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

### 1.3 EXECUTION

A. Examination

1. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
2. Proof-roll prepared subbase surface below decorative concrete paving to identify soft pockets and areas of excess yielding.
  - a. Completely proof-roll subbase in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph (5 km/h).
  - b. Proof-roll with a pneumatic-tired and loaded, 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes).
  - c. Correct subbase with soft spots and areas of pumping or rutting exceeding depth of 1/2 inch (13 mm) according to requirements in Division 31 Section "Earth Moving".



3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Remove loose material from compacted subbase surface immediately before placing concrete.
2. Protect adjacent construction from discoloration and spillage during application of color hardeners, release agents, stains, curing compounds, and sealers.

C. Edge Forms And Screed Construction

1. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
2. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

D. Steel Reinforcement

1. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
2. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
3. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
4. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
5. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum **2-inch (50-mm)** overlap to adjacent mats.

E. Joints

1. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
  - a. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
2. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
  - a. Continue steel reinforcement across construction joints unless otherwise indicated. Do not continue reinforcement through sides of paving strips unless otherwise indicated.
  - b. Butt Joints: Use bonding agent **OR** epoxy bonding adhesive, **as directed**, at joint locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
  - c. Keyed Joints: Provide preformed keyway-section forms or bulkhead forms with keys unless otherwise indicated. Embed keys at least **1-1/2 inches (38 mm)** into concrete.
  - d. Dowelled Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
3. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
  - a. Locate expansion joints at intervals of **50 feet (15.25 m)** unless otherwise indicated.
  - b. Extend joint fillers full width and depth of joint.
  - c. Terminate joint filler not less than **1/2 inch (13 mm)** or more than **1 inch (25 mm)** below finished surface if joint sealant is indicated.
  - d. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
  - e. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.

- f. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
  4. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent decorative concrete paving, **as directed**:
    - a. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with grooving tool to a **1/4-inch (6-mm) OR 3/8-inch (10-mm)**, **as directed**, radius. Repeat grooving of contraction joints after applying surface finishes. Eliminate grooving-tool marks on concrete surfaces.
      - 1) Tolerance: Ensure that grooved joints are within **3 inches (75 mm)** either way from centers of dowels.
    - b. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut **1/8-inch- (3-mm-)** wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.
      - 1) Tolerance: Ensure that sawed joints are within **3 inches (75 mm)** in both directions from center of dowels.
    - c. Doweled Contraction Joints: Install dowel bars and support assemblies at joints where indicated. Lubricate or coat with asphalt one-half of dowel length to prevent concrete bonding to one side of joint.
  5. Edging: After initial floating, tool edges of paving, gutters, curbs, and joints in concrete with an edging tool to a **1/4-inch (6-mm) OR 3/8-inch (10-mm)**, **as directed**, radius. Repeat tooling of edges after applying surface finishes. Eliminate edging tool marks on concrete surfaces.
- F. Concrete Placement
  1. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.
  2. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.
  3. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
  4. Comply with **ACI 301 (ACI 301M)** requirements for measuring, mixing, transporting, and placing concrete.
  5. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.
  6. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.
  7. Consolidate concrete according to **ACI 301 (ACI 301M)** by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.
    - a. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.
  8. Screed paving surface with a straightedge and strike off.
  9. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
  10. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
    - a. When air temperature has fallen to or is expected to fall below **40 deg F (4.4 deg C)**, uniformly heat water and aggregates before mixing to obtain a concrete mixture



temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) at point of placement.

- b. Do not use frozen materials or materials containing ice or snow.
  - c. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.
11. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:
- a. Cool ingredients before mixing to maintain concrete temperature below 90 deg F (32 deg C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
  - b. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
  - c. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

G. Float Finishing

- 1. General: Do not add water to concrete surfaces during finishing operations.
- 2. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

H. Integrally Colored Concrete Finish

- 1. Integrally Colored Concrete Finish: After final floating, apply the following finish:
  - a. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
  - b. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
  - c. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

I. Stenciling

- 1. Cut stencils to slab width and lay on wet concrete. Overlap "mortar joint" on trailing edge of each section of stencil onto leading "mortar joint" of previous section.
- 2. Trim stencils to fit slab and adjacent patterns.
- 3. Slightly embed stencil into concrete by rolling with stencil roller.
- 4. Apply pigmented mineral dry-shake hardener materials to concrete surfaces according to manufacturer's written instructions.
- 5. Stencil Rolling:
  - a. Apply pigmented powder release agent **OR** liquid release agent, **as directed**, according to manufacturer's written instructions prior to applying texture roller to surface of concrete.
  - b. Perform rolling operation to produce required texture on concrete surface.
- 6. Remove stencils when concrete has sufficiently cured to bear weight. Do not leave stencils in concrete overnight.
- 7. Remove debris with mechanical blower prior to application of curing compound. If release agent is applied, delay removal of debris for 24 hours, then flood area with low-pressure water hose, wetting release agent, and follow by cleaning surface with pressure washer.

J. Pigmented Mineral Dry-Shake Hardener

- 1. Pigmented Mineral Dry-Shake Hardener Finish: After initial floating, apply dry-shake materials to paving surfaces according to manufacturer's written instructions and as follows:

- a. Uniformly apply dry-shake hardener at a rate of **100 lb/100 sq. ft. (49 kg/10 sq. m)** unless greater amount is recommended by manufacturer to match paving color required.
  - b. Uniformly distribute approximately two-thirds of dry-shake hardener over the concrete surface with mechanical spreader; allow hardener to absorb moisture and embed it by power floating. Follow power floating with a second application of pigmented mineral dry-shake hardener, uniformly distributing remainder of material at right angles to first application to ensure uniform color, and embed hardener by final power floating.
  - c. After final power floating, apply the following finish:
    - 1) Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
    - 2) Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface, perpendicular to line of traffic, to provide a uniform, fine-line texture.
    - 3) Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface **1/16 to 1/8 inch (1.6 to 3 mm)** deep with a stiff-bristled broom, perpendicular to line of traffic.
  2. Pigmented Powder Release Agent: Uniformly distribute onto dry-shake-hardened and still-plastic concrete at a rate of **3 to 4 lb/100 sq. ft. (1.5 to 2 kg/10 sq. m)**.
  3. Liquid Release Agent: Uniformly mist surface of dry-shake-hardened and still-plastic concrete at a rate of **5 gal/1000 sq. ft. (0.2 L/sq. m)**.
- K. Stamping
1. Mat Stamping: After floating and while concrete is plastic, apply mat-stamped finish.
    - a. Pigmented Powder Release Agent: Uniformly distribute onto concrete at a rate of **3 to 4 lb/100 sq. ft. (1.5 to 2 kg/10 sq. m)**.
    - b. Liquid Release Agent: Apply liquid release agent to the concrete surface and the stamp mat. Uniformly mist surface of concrete at a rate of **5 gal/1000 sq. ft. (0.2 L/sq. m)**.
    - c. After application of release agent, accurately align and place stamp mats in sequence.
    - d. Uniformly load mats and press into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp mats. Hand stamp edges and surfaces unable to be imprinted by stamp mats.
    - e. Remove residual release agent according to manufacturer's written instructions, but no fewer than three days after stamping concrete. High-pressure-wash surface and joint patterns, taking care not to damage stamped concrete. Control, collect, and legally dispose of runoff.
  2. Tool Stamping: After floating and while concrete is plastic, apply tool-stamped finish.
    - a. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends **3 inches (75 mm)**, and secure to edge forms. Lightly broom surface to remove air bubbles.
    - b. Accurately align and place stamp tools in sequence and tamp into concrete to produce required imprint pattern and depth of imprint on concrete surface. Gently remove stamp tools. Hand stamp edges and surfaces unable to be imprinted by stamp tools.
    - c. Carefully remove polyethylene film immediately after tool stamping.
  3. Roller Stamping: After floating and while concrete is plastic, apply roller-stamped finish.
    - a. Cover surface with polyethylene film, stretch taut to remove wrinkles, lap sides and ends **3 inches (75 mm)**, and secure to edge forms. Lightly broom surface to remove air bubbles.
    - b. Accurately align roller and perform rolling operation to produce required imprint pattern and depth of imprint on concrete surface. Hand stamp surfaces inaccessible to roller.
    - c. Carefully remove polyethylene film immediately after roller stamping.
- L. Concrete Protection And Curing
1. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
  2. Comply with ACI 306.1 for cold-weather protection.
  3. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching **0.2 lb/sq. ft. x h (1 kg/sq. m x h)** before and during

finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

4. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.
5. Curing Compound: Apply curing compound immediately after final finishing. Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas that have been subjected to heavy rainfall within three hours after application. Maintain continuity of coating, and repair damage during curing period.
  - a. Cure integrally colored concrete with a pigmented, **as directed**, curing compound.
  - b. Cure concrete finished with pigmented mineral dry-shake hardener with a pigmented, **as directed**, curing compound.
6. Curing and Sealing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period.
7. Curing Paper: Cure with unwrinkled curing paper in pieces large enough to cover the entire width and edges of slab. Do not lap sheets. Fold curing paper down over paving edges and secure with continuous banks of earth to prevent displacement or billowing due to wind. Immediately repair holes or tears in paper.

#### M. Staining

1. Newly placed concrete paving shall be at least 14 **OR** 30, **as directed**, days old before staining.
2. Prepare surfaces according to manufacturer's written instructions and as follows:
  - a. Clean concrete thoroughly by scraping, applying solvents or stripping agents, sweeping and pressure washing, or scrubbing with a rotary floor machine and detergents recommended by stain manufacturer. Rinse until water is clear and allow surface to dry.
    - 1) Do not use acidic solutions to clean surfaces.
  - b. Test surfaces with droplets of water. If water beads and does not penetrate surface, or penetrates only in some areas, profile surfaces by acid etching, grinding, sanding, or abrasive blasting. Retest and continue profiling surface until water droplets immediately darken and uniformly penetrate concrete surfaces.
  - c. Apply acidic solution to dampened concrete surfaces, scrubbing with uncolored, acid-resistant nylon-bristle brushes until bubbling stops and concrete surface has texture of 120-grit sandpaper. Do not allow solution to dry on concrete surfaces. Rinse until water is clear. Control, collect, and legally dispose of runoff.
  - d. Neutralize concrete surfaces and rinse until water is clear. Test surface for residue with clean white cloth. Test surface according to ASTM F 710 to ensure pH is between 7 and 8.
3. Scoring: Score decorative jointing in paving surfaces **1/16 inch (1.6 mm)** deep with diamond blades to match pattern indicated. Rinse until water is clear. Score after **OR** before, **as directed**, staining.
  - a. Joint Width: **3/8 inch (10 mm)**.
4. Allow paving surface to dry before applying stain. Verify readiness of paving to receive stain according to ASTM D 4263 by tightly taping **18-by-18-inch (450-by-450-mm)**, **4-mil- (0.1-mm-)** thick polyethylene sheet to a representative area of paving surface. Apply stain only if no evidence of moisture has accumulated under sheet after 16 hours.
5. Reactive Stain: Apply reactive stain to paving surfaces according to manufacturer's written instructions and as follows:
  - a. Apply stain by uncolored bristle brush, roller, or high-volume, low-pressure sprayer and immediately scrub into concrete surface with uncolored, acid-resistant nylon-bristle brushes in continuous, circular motion. Do not spread stain after fizzing stops. Allow to dry four hours and repeat application of stain in sufficient quantity to obtain color consistent with approved mockup.
  - b. Remove stain residue after four hours by wet scrubbing with commercial-grade detergent recommended by stain manufacturer. Rinse until water is clear. Control, collect, and legally dispose of runoff.

6. Penetrating Stain: Apply penetrating stain to paving surfaces according to manufacturer's written instructions and as follows:
  - a. Apply first coat of stain to dry, clean surfaces by airless sprayer or by high-volume, low-pressure sprayer.
  - b. Allow to dry four hours and repeat application of stain in sufficient quantity to obtain color consistent with approved mockup.
  - c. Rinse until water is clear. Control, collect, and legally dispose of runoff.
- N. Sealer
  1. Clear Acrylic Sealer: Apply uniformly in two coats in continuous operations according to manufacturer's written instructions. Allow first coat to dry before applying second coat, at 90 degrees to the direction of the first coat using same application methods and rates.
    - a. Begin sealing dry surface no sooner than 14 days after concrete placement.
    - b. Allow stained concrete surfaces to dry before applying sealer.
    - c. Thoroughly mix slip-resistance-enhancing additive into sealer before applying sealer according to manufacturer's written instructions. Stir sealer occasionally during application to maintain even distribution of additive.
- O. Paving Tolerances
  1. Comply with tolerances in ACI 117 and as follows:
    - a. Elevation: **3/4 inch (19 mm)**.
    - b. Thickness: Plus **3/8 inch (10 mm)**, minus **1/4 inch (6 mm)**.
    - c. Surface: Gap below **10-foot- (3-m-)** long, unleveled straightedge not to exceed **1/2 inch (13 mm)**.
    - d. Lateral Alignment and Spacing of Dowels: **1 inch (25 mm)**.
    - e. Vertical Alignment of Dowels: **1/4 inch (6 mm)**.
    - f. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: **1/4 inch per 12 inches (6 mm per 300 mm)** of dowel.
    - g. Joint Spacing: **3 inches (75 mm)**.
    - h. Contraction Joint Depth: Plus **1/4 inch (6 mm)**, no minus.
    - i. Joint Width: Plus **1/8 inch (3 mm)**, no minus.
- P. Field Quality Control
  1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
  2. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:
    - a. Testing Frequency: Obtain at least one composite sample for each **100 cu. yd. (76 cu. m)** **OR 5000 sq. ft. (465 sq. m)**, **as directed**, or fraction thereof of each concrete mixture placed each day.
      - 1) When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
    - b. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.
    - c. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
    - d. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is **40 deg F (4.4 deg C)** and below and when it is **80 deg F (27 deg C)** and above, and one test for each composite sample.
    - e. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
    - f. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.
      - 1) A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

3. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).
4. Test results shall be reported in writing to the Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
5. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by the Owner but will not be used as sole basis for approval or rejection of concrete.
6. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by the Owner.
7. Decorative concrete paving will be considered defective if it does not pass tests and inspections.
8. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
9. Prepare test and inspection reports.

Q. Repairs And Protection

1. Remove and replace decorative concrete paving that is broken or damaged or does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by the Owner.
2. Detailing: Grind concrete "squeeze" left from tool placement. Color ground areas with slurry of color hardener mixed with water and bonding agent. Remove excess release agent with high-velocity blower.
3. Protect decorative concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.
4. Maintain decorative concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Final Completion inspections.

END OF SECTION 32 13 13 33

Task	Specification	Specification Description
32 13 13 33	03 31 13 00	Cement Concrete Pavement
32 13 13 33	03 31 13 00a	Roller Compacted Concrete Pavement
32 13 13 33	03 31 13 00c	Steel Reinforced Portland Cement Concrete Overlays
32 13 13 33	03 31 13 00d	Fiber Reinforced Portland Cement Concrete Overlays
32 13 73 13	32 01 13 61	Asphalt Paving
32 13 73 13	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 13 73 13	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 13 73 16	32 01 13 61	Asphalt Paving
32 13 73 16	32 01 13 61a	Crack Sealing Of Bituminous Pavements
32 13 73 16	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments
32 13 73 19	32 01 13 61	Asphalt Paving
32 13 73 19	32 01 13 61b	Spray Applications, Seal Coats, And Surface Treatments

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## SECTION 32 14 09 00 - EXTERIOR PLANTS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for exterior plants. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Plants.
  - b. Planting soils.
  - c. Tree stabilization.
  - d. Landscape edgings.
  - e. Tree grates.

#### C. Definitions

1. Backfill: The earth used to replace or the act of replacing earth in an excavation.
2. Balled and Burlapped Stock: Plants dug with firm, natural balls of earth in which they were grown, with ball size not less than sizes indicated **OR** diameter and depth recommended by ANSI Z60.1 for type and size of plant required, **as directed**; wrapped with burlap, tied, rigidly supported, and drum laced with twine with the root flare visible at the surface of the ball as recommended by ANSI Z60.1.
3. Balled and Potted Stock: Plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than sizes indicated **OR** diameter and depth recommended by ANSI Z60.1 for type and size of plant required, **as directed**.
4. Bare-Root Stock: Plants with a well-branched, fibrous-root system developed by transplanting or root pruning, with soil or growing medium removed, and with not less than minimum root spread according to ANSI Z60.1 for type and size of plant required.
5. Container-Grown Stock: Healthy, vigorous, well-rooted plants grown in a container, with a well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of plant required.
6. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
7. Fabric Bag-Grown Stock: Healthy, vigorous, well-rooted plants established and grown in-ground in a porous fabric bag with well-established root system reaching sides of fabric bag. Fabric bag size is not less than diameter, depth, and volume required by ANSI Z60.1 for type and size of plant.
8. Finish Grade: Elevation of finished surface of planting soil.
9. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
10. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
11. Pests: Living organisms that occur where they are not desired, or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
12. Planting Area: Areas to be planted.



13. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
14. Plant; Plants; Plant Material: These terms refer to vegetation in general, including trees, shrubs, vines, ground covers, ornamental grasses, bulbs, corms, tubers, or herbaceous vegetation.
15. Root Flare: Also called "trunk flare." The area at the base of the plant's stem or trunk where the stem or trunk broadens to form roots; the area of transition between the root system and the stem or trunk.
16. Stem Girdling Roots: Roots that encircle the stems (trunks) of trees below the soil surface.
17. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or the top surface of a fill or backfill before planting soil is placed.
18. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
19. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

D. Submittals

1. Product Data: For each type of product indicated, including soils.
2. Samples of mineral mulch.
3. Product certificates.
4. Maintenance Instructions: Recommended procedures to be established by the Owner for maintenance of plants during a calendar year.

E. Quality Assurance

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
  - a. Pesticide Applicator: State licensed, commercial.
2. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory.
  - a. The soil-testing laboratory shall oversee soil sampling.
  - b. Report suitability of tested soil for plant growth.
    - 1) State recommendations for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
    - 2) Report presence of problem salts, minerals, or heavy metals; if present, provide additional recommendations for corrective action.
3. Provide quality, size, genus, species, and variety of plants indicated, complying with applicable requirements in ANSI Z60.1.
4. Preinstallation Conference: Conduct conference at Project site.

F. Delivery, Storage, And Handling

1. Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws if applicable.
2. Bulk Materials:
  - a. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  - b. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  - c. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.
3. Deliver bare-root stock plants freshly dug. Immediately after digging up bare-root stock, pack root system in wet straw, hay, or other suitable material to keep root system moist until planting.

4. Do not prune trees and shrubs before delivery. Protect bark, branches, and root systems from sun scald, drying, wind burn, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of plants during shipping and delivery. Do not drop plants during delivery and handling.
5. Handle planting stock by root ball.
6. Store bulbs, corms, and tubers in a dry place at 60 to 65 deg F (16 to 18 deg C) until planting.
7. Deliver plants after preparations for planting have been completed, and install immediately. If planting is delayed more than six hours after delivery, set plants and trees in their appropriate aspect (sun, filtered sun, or shade), protect from weather and mechanical damage, and keep roots moist.
  - a. Heel-in bare-root stock. Soak roots that are in dry condition in water for two hours. Reject dried-out plants.
  - b. Set balled stock on ground and cover ball with soil, peat moss, sawdust, or other acceptable material.
  - c. Do not remove container-grown stock from containers before time of planting.
  - d. Water root systems of plants stored on-site deeply and thoroughly with a fine-mist spray. Water as often as necessary to maintain root systems in a moist, but not overly-wet condition.

G. Warranty

1. Special Warranty: Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
  - a. Failures include, but are not limited to, the following:
    - 1) Death and unsatisfactory growth, except for defects resulting from abuse, lack of adequate maintenance, or neglect by the Owner, or incidents that are beyond Contractor's control.
    - 2) Structural failures including plantings falling or blowing over.
    - 3) Faulty performance of tree stabilization, edgings, or tree grates.
    - 4) Deterioration of metals, metal finishes, and other materials beyond normal weathering.
  - b. Warranty Periods from Date of Planting Completion **OR** Final Completion, **as directed**:
    - 1) Trees, Shrubs, Vines, and Ornamental Grasses: 12 months.
    - 2) Ground Covers, Biennials, Perennials, and Other Plants: 12 **OR** Nine **OR** Six **OR** Three, **as directed**, months.
    - 3) Annuals: Three **OR** Two, **as directed**, months.

H. Maintenance Service

1. Initial Maintenance Service: Provide maintenance by skilled employees of landscape Installer. Maintain as required in Part 1.3. Begin maintenance immediately after plants are installed and continue until plantings are acceptably healthy and well established but for not less than maintenance period below.
  - a. Maintenance Period for Trees and Shrubs: 12 **OR** Six **OR** Three, **as directed**, months from date of planting completion **OR** Final Completion, **as directed**.
  - b. Maintenance Period for Ground Cover and Other Plants: Six **OR** Three, **as directed**, months from date of planting completion **OR** Final Completion, **as directed**.
2. Continuing Maintenance Proposal: From Installer to the Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

## 1.2 PRODUCTS

A. Plant Material

1. General: Furnish nursery-grown plants true to genus, species, variety, cultivar, stem form, shearing, and other features indicated in Plant Schedule or Plant Legend shown on Drawings and complying with ANSI Z60.1; and with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock, densely foliated when in leaf and free of disease, pests, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
  - a. Trees with damaged, crooked, or multiple leaders; tight vertical branches where bark is squeezed between two branches or between branch and trunk ("included bark"); crossing trunks; cut-off limbs more than **3/4 inch (19 mm)** in diameter; or with stem girdling roots will be rejected.
  - b. Collected Stock: Do not use plants harvested from the wild, from native stands, from an established landscape planting, or not grown in a nursery unless otherwise indicated.
2. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
3. Annuals and Biennials: Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.

B. Inorganic Soil Amendments

1. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
  - a. Class: T, with a minimum of 99 percent passing through **No. 8 (2.36-mm)** sieve and a minimum of 75 percent passing through **No. 60 (0.25-mm)** sieve.  
**OR**  
Class: O, with a minimum of 95 percent passing through **No. 8 (2.36-mm)** sieve and a minimum of 55 percent passing through **No. 60 (0.25-mm)** sieve.
  - b. Provide lime in form of ground dolomitic limestone **OR** calcitic limestone **OR** mollusk shells, **as directed**.
2. Sulfur: Granular, biodegradable, and containing a minimum of 90 percent sulfur, with a minimum of 99 percent passing through **No. 6 (3.35-mm)** sieve and a maximum of 10 percent passing through **No. 40 (0.425-mm)** sieve.
3. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
4. Aluminum Sulfate: Commercial grade, unadulterated.
5. Perlite: Horticultural perlite, soil amendment grade.
6. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through **No. 50 (0.30-mm)** sieve.
7. Sand: Clean, washed, natural or manufactured, and free of toxic materials.
8. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.  
**OR**  
Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

C. Organic Soil Amendments

1. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through **1-inch (25-mm) OR 3/4-inch (19-mm) OR 1/2-inch (13-mm)**, **as directed**, sieve; soluble salt content of 5 to 10 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
  - a. Organic Matter Content: 50 to 60 percent of dry weight.
  - b. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
2. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or granular texture, with a pH range of 3.4 to 4.8.

3. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
4. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
  - a. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of **0.15 lb/cu. ft. (2.4 kg/cu. m)** of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of **0.25 lb/cu. ft. (4 kg/cu. m)** of loose sawdust or ground bark.
5. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, debris, and material harmful to plant growth.

D. Fertilizers

1. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 **OR 4, as directed**, percent nitrogen and 10 **OR 20, as directed**, percent phosphoric acid.
2. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
3. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
  - a. Composition: **1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m)** of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
  - b. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
4. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
  - a. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.
  - b. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
5. Planting Tablets: Tightly compressed chip type, long-lasting, slow-release, commercial-grade planting fertilizer in tablet form. Tablets shall break down with soil bacteria, converting nutrients into a form that can be absorbed by plant roots.
  - a. Size: 5-gram **OR 10-gram OR 21-gram, as directed**, tablets.
  - b. Nutrient Composition: 20 percent nitrogen, 10 percent phosphorous, and 5 percent potassium, by weight plus micronutrients.
6. Chelated Iron: Commercial-grade FeEDDHA for dicots and woody plants, and commercial-grade FeDTPA for ornamental grasses and monocots.

E. Planting Soils

1. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 2 percent organic material content **OR** Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process **OR** Existing, in-place surface soil **OR** Imported topsoil or manufactured topsoil from off-site sources; do not obtain from agricultural land, bogs or marshes, **as directed**. Verify suitability of soil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
  - a. Ratio of Loose Compost to Topsoil by Volume: 1:4 **OR 1:3 OR 1:2, as directed**.
  - b. Ratio of Loose Sphagnum **OR** Muck, **as directed**, Peat to Topsoil by Volume: as directed by the Owner.
  - c. Ratio of Loose Wood Derivatives to Topsoil by Volume: as directed by the Owner.
  - d. Weight of Lime per **1000 Sq. Ft. (92.9 Sq. m)**: as directed by the Owner.

- e. Weight of Sulfur **OR** Iron Sulfate **OR** Aluminum Sulfate, **as directed**, per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
  - f. Weight of Agricultural Gypsum per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
  - g. Volume of Sand Plus 10 Percent Diatomaceous Earth **OR** Zeolites, **as directed**, per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
  - h. Weight of Bonemeal per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
  - i. Weight of Superphosphate per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
  - j. Weight of Commercial Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
  - k. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.
- F. Mulches
- 1. Organic Mulch: Shredded hardwood **OR** Ground or shredded bark **OR** Wood and bark chips **OR** Pine straw **OR** Salt hay or threshed straw **OR** Pine needles **OR** Peanut, pecan, and cocoa-bean shells, **as directed**.
  - 2. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through 1-inch (25-mm) sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings.
  - 3. Mineral Mulch: Rounded riverbed gravel or smooth-faced stone **OR** Crushed stone or gravel **OR** Marble chips **OR** Granite chips, **as directed**.
    - a. Size Range: 1-1/2 inches (38 mm) maximum, 3/4 inch (19 mm) minimum **OR** 3/4 inch (19 mm) maximum, 1/4 inch (6.4 mm) minimum, **as directed**.
    - b. Color: Uniform tan-beige color range acceptable to the Owner **OR** Readily available natural gravel color range, **as directed**.
- G. Weed-Control Barriers
- 1. Nonwoven Geotextile Filter Fabric: Polypropylene or polyester fabric, 3 oz./sq. yd. (101g/sq. m) minimum, composed of fibers formed into a stable network so that fibers retain their relative position. Fabric shall be inert to biological degradation and resist naturally-encountered chemicals, alkalis, and acids.
  - 2. Composite Fabric: Woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, 4.8 oz./sq. yd. (162 g/sq. m).
- H. Pesticides
- 1. General: Pesticide registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
  - 2. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
  - 3. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.
- I. Tree Stabilization Materials
- 1. Stakes and Guys:
    - a. Upright and Guy Stakes: Rough-sawn, sound, new hardwood **OR** softwood with specified wood pressure-preservative treatment, **as directed**, free of knots, holes, cross grain, and other defects, 2-by-2-inch nominal (38-by-38-mm actual) by length indicated, pointed at one end.
    - b. Wood Deadmen: Timbers measuring 8 inches (200 mm) in diameter and 48 inches (1200 mm) long, treated with specified wood pressure-preservative treatment.
    - c. Flexible Ties: Wide rubber or elastic bands or straps of length required to reach stakes or turnbuckles **OR** compression springs, **as directed**.
    - d. Guys and Tie Wires: ASTM A 641/A 641M, Class 1, galvanized-steel wire, two-strand, twisted, 0.106 inch (2.7 mm) in diameter.



- e. Tree-Tie Webbing: UV-resistant polypropylene or nylon webbing with brass grommets.
- f. Guy Cables: Five-strand, **3/16-inch- (4.8-mm-)** diameter, galvanized-steel cable, with zinc-coated turnbuckles **OR** compression springs, **as directed**, a minimum of **3 inches (75 mm)** long, with two **3/8-inch (10-mm)** galvanized eyebolts.
- g. Flags: Standard surveyor's plastic flagging tape, white, **6 inches (150 mm)** long.
- h. Proprietary Staking-and-Guying Devices: Proprietary stake and adjustable tie systems to secure each new planting by plant stem; sized as indicated and per manufacturer's written recommendations.
- 2. Root-Ball Stabilization Materials:
  - a. Upright Stakes and Horizontal Hold-Down: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, **2-by-2-inch nominal (38-by-38-mm actual)** by length indicated; stakes pointed at one end.
  - b. Wood Screws: ASME B18.6.1.
  - c. Proprietary Root-Ball Stabilization Devices: Proprietary at- or below-grade stabilization systems to secure each new planting by root ball; sized per manufacturer's written recommendations unless otherwise indicated.
- 3. Palm Bracing: Battens or blocks, struts, straps, and protective padding as indicated.
  - a. Battens or Blocks and Struts: Rough-sawn, sound, new hardwood or softwood, free of knots, holes, cross grain, and other defects, **2-by-4-inch nominal (38-by-89-mm actual)** by lengths indicated.
  - b. Straps: Adjustable steel or plastic package banding straps.
  - c. Padding: Burlap.
  - d. Proprietary Palm-Bracing Devices: Proprietary systems to secure each new planting by trunk; sized per manufacturer's written recommendations unless otherwise indicated.
- J. Landscape Edgings
  - 1. Wood Edging: Of sizes shown on Drawings, and wood stakes as follows:
    - a. Species: Western red cedar, all heart **OR** Southern pine with specified wood pressure-preservative treatment, **as directed**.
    - b. Stakes: Same species as edging, **1-by-2-inch nominal (19-by-38-mm actual)** by **18 inches (450 mm)** long, with galvanized nails for anchoring edging.
  - 2. Steel Edging: Standard commercial-steel edging, rolled edge, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.
    - a. Edging Size: **3/16 inch (4.8 mm)** wide by **4 inches (100 mm)** deep **OR 1/4 inch (6.4 mm)** wide by **5 inches (125 mm)** deep **OR 1/4 inch (6.4 mm)** wide by **4 inches (100 mm)** deep **OR 1/8 inch (3.2 mm)** wide by **4 inches (100 mm)** deep **OR 1/8 inch (3.2 mm)** wide by **6 inches (150 mm)** deep **OR 0.1 inch (2.5 mm)** wide by **4 inches (100 mm)** deep, **as directed**.
    - b. Stakes: Tapered steel, a minimum of **12 inches (300 mm)** **OR 15 inches (380 mm)**, **as directed**, long.
    - c. Accessories: Standard tapered ends, corners, and splicers.
    - d. Finish: Standard paint **OR** Zinc coated **OR** Unfinished, **as directed**.
    - e. Paint Color: Black **OR** Green **OR** Brown, **as directed**.
  - 3. Aluminum Edging: Standard-profile extruded-aluminum edging, **ASTM B 221 (ASTM B 221M)**, Alloy 6063-T6, fabricated in standard lengths with interlocking sections with loops stamped from face of sections to receive stakes.
    - a. Edging Size: **3/16 inch (4.8 mm)** wide by **5-1/2 inches (140 mm)** deep **OR 3/16 inch (4.8 mm)** wide by **4 inches (100 mm)** deep **OR 1/8 inch (3.2 mm)** wide by **5-1/2 inches (140 mm)** deep **OR 1/8 inch (3.2 mm)** wide by **4 inches (100 mm)** deep, **as directed**.
    - b. Stakes: Aluminum, **ASTM B 221 (ASTM B 221M)**, Alloy 6061-T6, approximately **1-1/2 inches (38 mm)** wide by **12 inches (300 mm)** long.
    - c. Finish: Manufacturer's standard paint **OR** Powder-coat paint **OR** Mill (natural aluminum) **OR** Black anodized, **as directed**.
    - d. Paint Color: Black **OR** Green **OR** Brown, **as directed**.

4. Plastic Edging: Standard black polyethylene or vinyl edging, V-lipped bottom **OR** horizontally grooved, **as directed**, extruded in standard lengths, with **9-inch (225-mm)** steel angle **OR** plastic, **as directed**, stakes.
  - a. Edging Size: **0.1 inch (2.5 mm)** wide by **5 inches (125 mm)** deep **OR** **0.07 inch (1.8 mm)** wide by **5 inches (125 mm)** deep, **as directed**.
  - b. Top Profile: Straight, with top **2 inches (50 mm)** being **1/4 inch (6.4 mm)** thick.
  - c. Top Profile: Round top, **1/2 inch (13 mm)** **OR** **1 inch (25 mm)**, **as directed**, in diameter.
  - d. Accessories: Manufacturer's standard alignment clips or plugs.

#### K. Tree Grates

1. Tree Grates and Frames: ASTM A 48/A 48M, **Class 35 (Class 250)** or better, gray-iron castings of shape, pattern, and size indicated.  
**OR**  
Tree Grates and Frames: ASTM A 48/A 48M, **Class 35 (Class 250)** or better, gray-iron castings and ASTM A 36/A 36M steel-angle frames of shape, pattern, and size indicated; steel frames hot-dip galvanized.
2. Shape and Size: As indicated **OR** Round, **36 inches (914 mm)** in diameter **OR** Round, **72 inches (1828 mm)** in diameter **OR** **48 inches (1219 mm)** square **OR** **60 inches (1524 mm)** square **OR** Rectangular, **36 by 60 inches (914 by 1524 mm)** **OR** Rectangular, **48 by 72 inches (1219 by 1828 mm)**, **as directed**.
3. Finish: As fabricated **OR** Powder-coat finish, **as directed**.
  - a. Color: Low-gloss black **OR** dark brown **OR** dark green **OR** dark gray, **as directed**.

#### L. Miscellaneous Products

1. Wood Pressure-Preservative Treatment: AWPAC2, with waterborne preservative for soil and freshwater use, acceptable to authorities having jurisdiction, and containing no arsenic; including ammoniacal copper arsenate, ammoniacal copper zinc arsenate, and chromated copper arsenate.
2. Root Barrier: Black, molded, modular panels manufactured with 50 percent recycled polyethylene plastic with ultraviolet inhibitors, **85 mils (2.2 mm)** thick, with vertical root deflecting ribs protruding **3/4 inch (19 mm)** out from panel, and each panel **18 inches (457 mm)** **OR** **24 inches (610 mm)**, **as directed**, wide.
3. Antidesiccant: Water-insoluble emulsion, permeable moisture retarder, film forming, for trees and shrubs. Deliver in original, sealed, and fully labeled containers and mix according to manufacturer's written instructions.
4. Burlap: Non-synthetic, biodegradable.
5. Planter Drainage Gravel: Washed, sound crushed stone or gravel complying with ASTM D 448 for Size No. 8.
6. Planter Filter Fabric: Woven **OR** Nonwoven, **as directed**, geotextile manufactured for separation applications and made of polypropylene, polyolefin, or polyester fibers or combination of them.
7. Mycorrhizal Fungi: Dry, granular inoculant containing at least 5300 spores per **lb (0.45 kg)** of vesicular-arbuscular mycorrhizal fungi and 95 million spores per **lb (0.45 kg)** of ectomycorrhizal fungi, 33 percent hydrogel, and a maximum of 5.5 percent inert material.

### 1.3 EXECUTION

#### A. Preparation

1. Protect structures, utilities, sidewalks, pavements, and other facilities and turf areas and existing plants from damage caused by planting operations.
2. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
3. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Architect's acceptance of layout before excavating or planting. Make minor adjustments as required.

4. Lay out plants at locations directed by Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.
  5. Apply antidesiccant to trees and shrubs using power spray to provide an adequate film over trunks (before wrapping), branches, stems, twigs, and foliage to protect during digging, handling, and transportation.
    - a. If deciduous trees or shrubs are moved in full leaf, spray with antidesiccant at nursery before moving and again two weeks after planting.
  6. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.
- B. Planting Area Establishment
1. Loosen subgrade of planting areas to a minimum depth of **4 inches (100 mm) OR 6 inches (150 mm) OR 8 inches (200 mm) OR 12 inches (300 mm), as directed**. Remove stones larger than **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm), as directed**, in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off the Owner's property.
    - a. Apply superphosphate fertilizer directly to subgrade before loosening.
    - b. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
      - 1) Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
      - 2) Mix lime with dry soil before mixing fertilizer.
    - c. Spread planting soil to a depth of **4 inches (100 mm) OR 6 inches (150 mm) OR 8 inches (200 mm) OR 12 inches (300 mm), as directed**, but not less than required to meet finish grades after natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
      - 1) Spread approximately one-half the thickness of planting soil over loosened subgrade. Mix thoroughly into top **2 inches (50 mm) OR 4 inches (100 mm), as directed**, of subgrade. Spread remainder of planting soil.
  2. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Roll and rake, remove ridges, and fill depressions to meet finish grades.
  3. Before planting, obtain the Owner's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
  4. Application of Mycorrhizal Fungi: At time directed by the Owner, broadcast dry product uniformly over prepared soil at application rate indicated on Drawings.
- C. Excavation For Trees And Shrubs
1. Planting Pits and Trenches: Excavate circular planting pits with sides sloping inward at a 45-degree angle. Excavations with vertical sides are not acceptable. Trim perimeter of bottom leaving center area of bottom raised slightly to support root ball and assist in drainage away from center. Do not further disturb base. Ensure that root ball will sit on undisturbed base soil to prevent settling. Scarify sides of planting pit smeared or smoothed during excavation.
    - a. Excavate approximately three times as wide as ball diameter for balled and burlapped **OR** balled and potted **OR** container-grown **OR** fabric bag-grown, **as directed**, stock.
    - b. Excavate at least **12 inches (300 mm)** wider than root spread and deep enough to accommodate vertical roots for bare-root stock.
    - c. Do not excavate deeper than depth of the root ball, measured from the root flare to the bottom of the root ball.
    - d. If area under the plant was initially dug too deep, add soil to raise it to the correct level and thoroughly tamp the added soil to prevent settling.
    - e. Maintain required angles of repose of adjacent materials as shown on the Drawings. Do not excavate subgrades of adjacent paving, structures, hardscapes, or other new or existing improvements.
    - f. Maintain supervision of excavations during working hours.
    - g. Keep excavations covered or otherwise protected overnight **OR** after working hours **OR** when unattended by Installer's personnel, **as directed**.



- h. If drain tile is shown on Drawings or required under planting areas, excavate to top of porous backfill over tile.
  2. Subsoil and topsoil removed from excavations may **OR** may not, **as directed**, be used as planting soil.
  3. Obstructions: Notify the Owner if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
    - a. Hardpan Layer: Drill **6-inch- (150-mm-)** diameter holes, **24 inches (600 mm)** apart, into free-draining strata or to a depth of **10 feet (3 m)**, whichever is less, and backfill with free-draining material.
  4. Drainage: Notify the Owner if subsoil conditions evidence unexpected water seepage or retention in tree or shrub planting pits.
  5. Fill excavations with water and allow to percolate away before positioning trees and shrubs.
- D. Tree, Shrub, And Vine Planting
1. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1. If root flare is not visible, remove soil in a level manner from the root ball to where the top-most root emerges from the trunk. After soil removal to expose the root flare, verify that root ball still meets size requirements.
  2. Remove stem girdling roots and kinked roots. Remove injured roots by cutting cleanly; do not break.
  3. Set balled and burlapped stock plumb and in center of planting pit or trench with root flare **1 inch (25 mm)** above **OR 2 inches (50 mm)** above, **as directed**, adjacent finish grades.
    - a. Use planting soil for backfill.
    - b. After placing some backfill around root ball to stabilize plant, carefully cut and remove burlap, rope, and wire baskets from tops of root balls and from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
    - c. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
    - d. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about **1 inch (25 mm)** from root tips; do not place tablets in bottom of the hole.
    - e. Continue backfilling process. Water again after placing and tamping final layer of soil.
  4. Set balled and potted **OR** container-grown, **as directed**, stock plumb and in center of planting pit or trench with root flare **1 inch (25 mm)** above **OR 2 inches (50 mm)** above, **as directed**, adjacent finish grades.
    - a. Use planting soil for backfill.
    - b. Carefully remove root ball from container without damaging root ball or plant.
    - c. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.
    - d. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about **1 inch (25 mm)** from root tips; do not place tablets in bottom of the hole.
    - e. Continue backfilling process. Water again after placing and tamping final layer of soil.
  5. Set fabric bag-grown stock plumb and in center of planting pit or trench with root flare **1 inch (25 mm)** above **OR 2 inches (50 mm)** above, **as directed**, adjacent finish grades.
    - a. Use planting soil for backfill.
    - b. Carefully remove root ball from fabric bag without damaging root ball or plant. Do not use planting stock if root ball is cracked or broken before or during planting operation.
    - c. Backfill around root ball in layers, tamping to settle soil and eliminate voids and air pockets. When planting pit is approximately one-half filled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed.

- d. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside the root ball about **1 inch (25 mm)** from root tips; do not place tablets in bottom of the hole.
  - e. Continue backfilling process. Water again after placing and tamping final layer of soil.
  - f. Set and support bare-root stock in center of planting pit or trench with root flare **1 inch (25 mm)** above **OR 2 inches (50 mm)** above, **as directed**, adjacent finish grade.
6. Use planting soil for backfill.
    - a. Spread roots without tangling or turning toward surface, and carefully work backfill around roots by hand. Puddle with water until backfill layers are completely saturated. Plumb before backfilling, and maintain plumb while working backfill around roots and placing layers above roots.
    - b. Place planting tablets in each planting pit when pit is approximately one-half filled; in amounts recommended in soil reports from soil-testing laboratory. Place tablets beside soil-covered roots about **1 inch (25 mm)** from root tips; do not place tablets in bottom of the hole or touching the roots.
    - c. Continue backfilling process. Water again after placing and tamping final layer of soil.
  7. When planting on slopes, set the plant so the root flare on the uphill side is flush with the surrounding soil on the slope; the edge of the root ball on the downhill side will be above the surrounding soil. Apply enough soil to cover the downhill side of the root ball.
- E. Mechanized Tree Spade Planting
1. Trees shall **OR** may, **as directed**, be planted with an approved mechanized tree spade at the designated locations. Do not use tree spade to move trees larger than the maximum size allowed for a similar field-grown, balled-and-burlapped root-ball diameter according to ANSI Z60.1, or larger than the manufacturer's maximum size recommendation for the tree spade being used, whichever is smaller.
  2. When extracting the tree, center the trunk within the tree spade and move tree with a solid ball of earth.
  3. Cut exposed roots cleanly during transplanting operations.
  4. Use the same tree spade to excavate the planting hole as was used to extract and transport the tree.
  5. Plant trees as shown on Drawings, following procedures in "Tree, Shrub, and Vine Planting" Article.
  6. Where possible, orient the tree in the same direction as in its original location.
- F. Tree, Shrub, And Vine Pruning
1. Remove only dead, dying, or broken branches. Do not prune for shape.
  2. Prune, thin, and shape trees, shrubs, and vines as directed by Architect.
  3. Prune, thin, and shape trees, shrubs, and vines according to standard professional horticultural and arboricultural practices. Unless otherwise indicated by Architect, do not cut tree leaders; remove only injured, dying, or dead branches from trees and shrubs; and prune to retain natural character.
  4. Do not apply pruning paint to wounds.
- G. Tree Stabilization
1. Install trunk stabilization as follows unless otherwise indicated:
    - a. Upright Staking and Tying: Stake trees of **2- through 5-inch (50- through 125-mm)** caliper. Stake trees of less than **2-inch (50-mm)** caliper only as required to prevent wind tip out. Use a minimum of two stakes of length required to penetrate at least **18 inches (450 mm)** below bottom of backfilled excavation and to extend to the dimension shown on Drawings **OR** at least **72 inches (1830 mm)** **OR** one-third of trunk height, **as directed**, above grade. Set vertical stakes and space to avoid penetrating root balls or root masses.
    - b. Use two stakes for trees up to **12 feet (3.6 m)** high and **2-1/2 inches (63 mm)** or less in caliper; three stakes for trees less than **14 feet (4.2 m)** high and up to **4 inches (100 mm)** in caliper. Space stakes equally around trees.

- c. Support trees with bands of flexible ties at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.  
**OR**  
Support trees with two strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk. Allow enough slack to avoid rigid restraint of tree.
2. Staking and Guying: Stake and guy trees more than **14 feet (4.2 m)** in height and more than **3 inches (75 mm)** in caliper unless otherwise indicated. Securely attach no fewer than three guys to stakes **30 inches (760 mm)** long, driven to grade.
  - a. Site-Fabricated Staking-and-Guying Method:
    - 1) For trees more than **6 inches (150 mm)** in caliper, anchor guys to wood deadmen buried at least **36 inches (900 mm)** below grade. Provide turnbuckle **OR** compression spring, **as directed**, for each guy wire and tighten securely.
    - 2) Support trees with bands of flexible ties at contact points with tree trunk and reaching to turnbuckle **OR** compression spring, **as directed**. Allow enough slack to avoid rigid restraint of tree.
    - 3) Support trees with strands of cable or multiple strands of tie wire, connected to the brass grommets of tree-tie webbing at contact points with tree trunk and reaching to turnbuckle **OR** compression spring, **as directed**. Allow enough slack to avoid rigid restraint of tree.
    - 4) Attach flags to each guy wire, **30 inches (760 mm)** above finish grade.  
**OR**  
Paint turnbuckles **OR** compression springs, **as directed**, with luminescent white paint.
  - b. Proprietary Staking and Guying Device: Install staking and guying system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.
3. Root-Ball Stabilization: Install at- or below-grade stabilization system to secure each new planting by the root ball unless otherwise indicated.
  - a. Wood Hold-Down Method: Place vertical stakes against side of root ball and drive them into subsoil; place horizontal wood hold-down stake across top of root ball and screw at each end to one of the vertical stakes.
    - 1) Install stakes of length required to penetrate at least to the dimension shown on Drawings **OR 18 inches (450 mm)**, **as directed**, below bottom of backfilled excavation. Saw stakes off at horizontal stake.
    - 2) Install screws through horizontal hold-down and penetrating at least **1 inch (25 mm)** into stakes. Predrill holes if necessary to prevent splitting wood.
    - 3) Install second set of stakes on other side of root trunk for larger trees as indicated.
  - b. Proprietary Root-Ball Stabilization Device: Install root-ball stabilization system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.
4. Palm Bracing: Install bracing system at three or more places equally spaced around perimeter of trunk to secure each palm until established unless otherwise indicated.
  - a. Site-Fabricated Palm-Bracing Method:
    - 1) Place battens over padding and secure battens in place around trunk perimeter with at least two straps, tightened to prevent displacement. Ensure that straps do not contact trunk.
    - 2) Place diagonal braces and cut to length. Secure upper ends of diagonal braces with galvanized nails into battens or into nail-attached blocks on battens. Do not drive nails, screws, or other securing devices into palm trunk; do not penetrate palm trunk in any fashion. Secure lower ends of diagonal braces with stakes driven into ground to prevent outward slippage of braces.
  - b. Proprietary Palm-Bracing Device: Install palm-bracing system sized and positioned as recommended by manufacturer unless otherwise indicated and according to manufacturer's written instructions.

H. Root-Barrier Installation

1. Install root barrier where trees are planted within **60 inches (1500 mm) OR 48 inches (1200 mm), as directed**, of paving or other hardscape elements, such as walls, curbs, and walkways unless otherwise shown on Drawings.
2. Align root barrier vertically **OR** with bottom edge angled at 20 degrees away from the paving or other hardscape element, **as directed**, and run it linearly along and adjacent to the paving or other hardscape elements to be protected from invasive roots.
3. Install root barrier continuously for a distance of **60 inches (1500 mm)** in each direction from the tree trunk, for a total distance of **10 feet (3 m)** per tree. If trees are spaced closer, use a single continuous piece of root barrier.
  - a. Position top of root barrier flush with finish grade **OR 1/2 inch (13 mm)** above finish grade **OR** per manufacturer's recommendations, **as directed**.
  - b. Overlap root barrier a minimum of **12 inches (300 mm)** at joints.
  - c. Do not distort or bend root barrier during construction activities.
  - d. Do not install root barrier surrounding the root ball of tree.

I. Planting In Planters

1. Place a layer of drainage gravel at least **4 inches (100 mm)** thick in bottom of planter. Cover bottom with filter fabric and wrap filter fabric **4 inches (100 mm) OR 6 inches (150 mm), as directed**, up on all sides. Duct tape along the entire top edge of the filter fabric, to secure the filter fabric against the sides during the soil-filling process.
2. Fill planter with lightweight on-structure planting soil. Place soil in lightly compacted layers to an elevation of **1-1/2 inches (38 mm)** below top of planter, allowing natural settlement.

J. Ground Cover And Plant Planting

1. Set out and space ground cover and plants other than trees, shrubs, and vines **9 inches (225 mm) apart OR 12 inches (300 mm) apart OR 18 inches (450 mm) apart OR 24 inches (600 mm) apart OR as indicated, as directed**, in even rows with triangular spacing.
2. Use planting soil for backfill.
3. Dig holes large enough to allow spreading of roots.
4. For rooted cutting plants supplied in flats, plant each in a manner that will minimally disturb the root system but to a depth not less than two nodes.
5. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
6. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
7. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

K. Planting Area Mulching

1. Install weed-control barriers before mulching according to manufacturer's written instructions. Completely cover area to be mulched, overlapping edges a minimum of **6 inches (150 mm) OR 12 inches (300mm), as directed**, and secure seams with galvanized pins.
2. Mulch backfilled surfaces of planting areas and other areas indicated.
  - a. Trees and Tree-like Shrubs in Turf Areas: Apply organic **OR** mineral, **as directed**, mulch ring of **2-inch (50-mm) OR 3-inch (75-mm), as directed**, average thickness, with **12-inch (300-mm) OR 24-inch (600-mm) OR 36-inch (900-mm), as directed**, radius around trunks or stems. Do not place mulch within **3 inches (75 mm) OR 6 inches (150 mm), as directed**, of trunks or stems.
  - b. Organic Mulch in Planting Areas: Apply **2-inch (50-mm) OR 3-inch (75-mm), as directed**, average thickness of organic mulch extending **12 inches (300 mm)** beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level with adjacent finish grades. Do not place mulch within **3 inches (75 mm) OR 6 inches (150 mm), as directed**, of trunks or stems.
  - c. Mineral Mulch in Planting Areas: Apply **2-inch (50-mm) OR 3-inch (75-mm), as directed**, average thickness of mineral mulch extending **12 inches (300 mm)** beyond edge of individual planting pit or trench and over whole surface of planting area, and finish level



with adjacent finish grades. Do not place mulch within **3 inches (75 mm) OR 6 inches (150 mm)**, **as directed**, of trunks or stems.

L. Edging Installation

1. Wood Edging: Install edging where indicated. Mitre cut joints and connections at a 45 degree angle. Fasten each cut joint or connection with two galvanized nails. Anchor with wood stakes spaced up to **36 inches (900 mm)** apart, driven at least **1 inch (25 mm)** below top elevation of edging. Use two galvanized nails per stake to fasten edging, of length as needed to penetrate both edging and stake and provide **1/2-inch (13-mm)** clinch at point. Predrill stakes if needed to avoid splitting. Replace stakes that crack or split during installation process.
2. Steel Edging: Install steel edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately **30 inches (760 mm)** apart, driven below top elevation of edging.
3. Aluminum Edging: Install aluminum edging where indicated according to manufacturer's written instructions. Anchor with aluminum stakes spaced approximately **36 inches (900 mm) OR 48 inches (1200 mm)**, **as directed**, apart, driven below top elevation of edging.
4. Plastic Edging: Install plastic edging where indicated according to manufacturer's written instructions. Anchor with steel stakes spaced approximately **36 inches (900 mm) OR 48 inches (1200 mm)**, **as directed**, apart, driven through upper base grooves or V-lip of edging.
5. Shovel-Cut Edging: Separate mulched areas from turf areas, curbs, and paving with a 45-degree, **4- to 6-inch- (100- to 150-mm-)** deep, shovel-cut edge as shown on Drawings.

M. Tree Grate Installation

1. Tree Grates: Set grate segments flush with adjoining surfaces as shown on Drawings. Shim from supporting substrate with soil-resistant plastic. Maintain a **3-inch- (75-mm-)** minimum growth radius around base of tree; break away units of casting, if necessary, according to manufacturer's written instructions.

N. Plant Maintenance

1. Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, mulching, restoring planting saucers, adjusting and repairing tree-stabilization devices, resetting to proper grades or vertical position, and performing other operations as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease.
2. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace mulch materials damaged or lost in areas of subsidence.
3. Apply treatments as required to keep plant materials, planted areas, and soils free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards. Treatments include physical controls such as hosing off foliage, mechanical controls such as traps, and biological control agents.

O. Pesticide Application

1. Apply pesticides and other chemical products and biological control agents in accordance with authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with the Owner's operations and others in proximity to the Work. Notify the Owner before each application is performed.
2. Pre-Emergent Herbicides (Selective and Non-Selective): Apply to tree, shrub, and ground-cover areas in accordance with manufacturer's written recommendations. Do not apply to seeded areas.
3. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.

P. Cleanup And Protection

1. During planting, keep adjacent paving and construction clean and work area in an orderly condition.



2. Protect plants from damage due to landscape operations and operations of other contractors and trades. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.
3. After installation and before Final Completion, remove nursery tags, nursery stakes, tie tape, labels, wire, burlap, and other debris from plant material, planting areas, and Project site.

Q. Disposal

1. Remove surplus soil and waste material including excess subsoil, unsuitable soil, trash, and debris and legally dispose of them off the Owner's property.

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## SECTION 32 14 11 00 - ASPHALT CONCRETE SIDEWALKS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of asphalt concrete sidewalks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Asphaltic Concrete:

1. Hot-Mixed, Hot-Laid Bituminous Paving Mixtures: ASTM D 3515.
2. Plant-Mixed, Stockpiled Asphalt Cold Mixes: Asphalt Institute Manual MS-14.

#### B. Bituminous Prime: ASTM D 2027, Grades MC-30 or MC-70; ASTM D 2028, Grade RC-70; or ASTM D 2026, Grade SC-70.

#### C. Base Course: ASTM D 2940.

#### D. Bituminous Tack Coat: ASTM D 977, Grades RS-1, MS-1 or SS-1h; ASTM D 2027, Grade MC-30; ASTM D 2028, Grade RC-70; ASTM D 2026, Grade SC-70; or ASTM D 2397, Grades CRS-1 or CSS-1.

#### E. Seal Coat: ASTM D 2027, Grade HC-250 or MC-800; or D 2028, Grade RC-250 or RC-800.

#### F. Slurry Coat Mixture shall be comprised of 70 percent sand or fine aggregate, 10 percent water, and 20 percent liquid or emulsified asphalt.

1. Fine Aggregate: ASTM D 1073, Grade 2.
2. Emulsified Asphalt: ASTM D 977, Grades SS-1 or SS-1h.

### 1.3 EXECUTION

#### A. Application Temperatures: Application temperatures for all asphalt materials shall comply with provisions of the Asphalt Institute publications and the applicable ASTM standards.

#### B. Subgrade: Construct the subgrade for walkway replacement true to grade and compact as required.

#### C. Base Course

1. Placing: Spread the base course material evenly upon the prepared subgrade, in a layer of such depth that when compacted the layer will be uniform and of the thickness required.
2. Compaction: Immediately following the spreading of the material, compact the base course with equipment to a density as required.

#### D. Surface Course

1. Placing: Apply prime coat, and allow it to cure. The placing of the mixture shall be continuous. Paint all contact surfaces of previously constructed sidewalk with a tack coat of rapid-setting liquid asphalt just before the fresh mixture is placed.





2. Forms: Set forms with the upper edge true to line and hold grade rigidly in place by stakes placed on the outside of the forms and set flush with the top edge of the forms.
3. Compaction: Immediately following the placement of the asphalt concrete mixture, compact the surface course with equipment to a density as required.
4. Backfilling: After removing the forms and debris, backfill the exposed or excavated area adjoining the sidewalk with granular material, grade, and compact to conform to the surrounding area.

E. Patching

1. For Repair Operations Involving Raveling, Heaving, Spalling, and Alligatoring: Cut asphalt concrete paving back to solid material, making cut area rectangular with vertical sides. Remove deteriorated pavement including base material if required. Replace base course, compact, and tack coat the base material and the vertical surfaces of cut area. Fill area with new asphalt concrete and compact level with existing walkway. Dust patched area with sand or mineral dust.
2. Pothole Repair: Cut rectangular hole around pothole back to solid pavement leaving straight, vertical edges. Remove loose material and water to firm base. Fill holes and compact to within 3 inches of the surface in layers not exceeding 6 inches with either base material or asphalt mixture. Apply tack coat to base material and vertical edges. On the surface layer, fill with asphalt mixture and mound to such height that when compacted the mix will be level with surrounding walkway surface. Dust patched area with sand or mineral dust.
3. Low Spot or Depression Repair: Determine limits of depression with straightedge, and mark outline with crayon. Apply tack coat, 0.05 to 0.15 gallon per square yard, to the cleaned area, and allow to cure. Spread area with asphalt concrete mix and feather edge by raking and manipulation of the material. Roll and compact area to surrounding walkway level. Recheck with straightedge. Apply a sand seal to the patched area to prevent entrance of water.
4. Polished Aggregate Repair: Clean and dry area thoroughly. Apply tack coat at a rate of 0.05 to 0.15 gallon per square yard; overlay area with new asphalt concrete mix to a minimum 1-1/2 inch thickness and feather to adjoining walkway surfaces. Roll with pneumatic or steel rollers.
5. Damaged Edging Repair: Remove damaged or deteriorated edging materials and replace.
6. Prime Coat: Prime new base course with MC-70 liquid asphalt at a rate of 0.20 to 0.30 gallon per square yard. Take care to apply to more asphalt than will penetrate into the base course during curing. Blot excess prime with sand before the surfacing material is applied.
7. Tack Coat: Surfaces and cut edges of existing asphalt concrete shall be given a tack coat of MC-70 liquid asphalt at a rate of 0.05 to 0.15 gallon per square yard. After application of the tack coat, allow time for the material to cure before surfacing and patching material is placed.
8. Seal Coat Spray Application: Walkway surfaces that are to be sealed shall receive a liquid asphalt coat applied at a rate of 0.15 to 0.20 gallon per square yard, along with a fine aggregate at a rate of 15 to 20 pounds per square yard.

- F. Crack Repair: Fill cracks after drying with liquid asphalt, sand asphalt emulsion water mixture, or slurry seal. After thorough cleaning, work the mixture into cracks by broom or squeegee. Cracks 1/8 to 1/2 inch width shall be slurry sealed and filled with liquid asphalt. Dust repaired cracks with fine aggregate or mineral dust to prevent cracking. Final thickness of the slurry seal shall be 1/8 inch minimum.

END OF SECTION 32 14 11 00

## SECTION 32 14 11 00a - MISCELLANEOUS SIDEWALKS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of miscellaneous sidewalks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Aggregate shall comply with the following:

1. Surface Course Aggregates shall be well-graded, crushed stone, 3/4- to 1-1/4 inch size, consisting of clean, sound, durable particles.
2. Masonry Grout Aggregate: ASTM C 404, Size 2.

#### B. Base Course: Base course material shall be a granular dense-graded, high-quality compactable material.

#### C. Ready-Mixed Concrete: Ready-mixed concrete shall comply with ASTM C 94. The concrete shall attain a minimum compressive strength of 3,000 psi at 28 days.

#### D. Portland Cement Concrete: Cement shall comply with ASTM C 150.

#### E. Joint Filler: Masonry joint filler shall be Portland cement concrete mix with cement complying with ASTM C 150.

#### F. Masonry Units: Color and texture shall match the existing as nearly as is practicable.

#### G. Wood and Preservatives: Footboards and supports shall be 1-1/2 inch thick Number 1 dense Douglas fir or yellow pine lumber, pressure-treated with chromated copper arsenate (CCA) preservative complying with applicable ASTM Standards. Retention shall be a minimum of 0.25 pounds per cubic foot.

### 1.3 EXECUTION

#### A. Base Course Repair: Remove material in soft spots to such depth required to provide a firm foundation for surface materials and fill with granular material of a quality that will compact when moistened. Roll or tamp this material to obtain the proper density.

#### B. Surface Repair

1. Aggregate Walkways: Spread the surface material evenly on the base course in a layer of such depth that when compacted, the layer will be uniform with a minimum thickness of 4 inches.
2. Joint Filling: Completely remove and clean the joint of all loose joint material, dirt, clay, or other foreign matter. Fill the joint flush with concrete to provide a uniform surface.
3. Wood Walkways: Secure wood members with galvanized nails, screws, bolts, or other approved fasteners to ensure tight joints.



4. Masonry Walkways: New or salvaged masonry units will be placed on a 3/4-inch mortar setting bed with mortar joints matching the existing walkway. Place the setting bed on a fresh 3-inch thick Portland cement concrete slab.

END OF SECTION 32 14 11 00a

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## SECTION 32 14 11 00b - PRECAST SIDEWALKS AND PAVERS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of precast sidewalks and pavers. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.
  - a. For stone varieties proposed for use on Project, include data on physical properties specified or required by referenced ASTM standards.
2. Stone Samples: For each color, grade, finish, and variety of stone required.

### 1.2 PRODUCTS

- A. Precast Concrete Patio Blocks: ASTM C 936. Natural or colored, minimum 2 inches thick.

- B. Exposed Aggregate or Granite: ASTM C 615 and National Building Granite Quarries Association, Inc.

1. Exposed Limestone: Limestone (Oolitic), ASTM C 568, Category II.
2. Exposed White Tumblestone Aggregate: As required to meet project requirements.

#### C. Stone Pavers

1. Bluestone Flagging Paver: Irregular cut, 1 inch thick.
2. White Marble, Crushed Stone: ASTM C 503 and Marble Institute of America (MIA), 3 inches thick.
3. Bluestone, Crushed Stone: 3 inches thick.
4. Natural Cleft Slate: ASTM C 629, 3/4-inch irregular cut, 1/2-inch random rectangular cut, or 1/4-inch random rectangular butted joints.

- D. Granite Blocks: Blocks shall be 3 to 5 inches thick and comply with requirements of ASTM C 615 and National Building Granite Quarries Association, Inc. Sizes shall be 3-1/2 inches square; 4 to 12 inches by 3 to 5 inches; and 6 to 15 inches by 3 to 6 inches.

#### E. Mortar and Grout

1. Portland Cement: ASTM C 150 and the staining requirements of ASTM C 91.
2. Masonry Cement: ASTM C 91, non-staining.
3. Hydrated Lime: ASTM C 207, Type S.
4. Sand: ASTM C 144.
  - a. White Pointing Mortar: Natural white sand or ground white stone.
  - b. Colored Pointing Mortar: Marble, granite, or sound stone.

### 1.3 EXECUTION

#### A. Preparation

1. Clean stone or concrete block with clear water.
2. Ferrous Metal: Apply a heavy coat of bituminous paint on metal surfaces in contact with block.

#### B. Installation

1. Expansion Joints: Install continuous strips of preformed joint filler.



2. Clean sub-base and saturate with clean water.
3. Slush Coat: Apply 1/16-in. thick slush coat of cement grout over concrete sub-base about 15 minutes prior to placing setting bed.
4. Setting Bed: Mix one 94-lb. bag of cement to 3 cu. ft. of sand. Use only enough water to produce a moist surface when setting bed is ready for setting of stone. Spread and screed to a uniform thickness.
5. Set stone or concrete block before initial set of cement bed occurs. Wet stone or block thoroughly before setting. Apply a thin layer of neat cement paste 1/32-in. to 1/16-in. thick to setting bed, or bottom of stone or block.
6. Grout joints as soon as possible after initial set of setting bed and tool slightly concave. Use grout mix of one bag Portland cement to 2 cu. ft. sand. Cure grout by maintaining in a moist condition for 7 days. Do not permit traffic on surface during setting of units or for at least 24 hours after final grouting of joints.

END OF SECTION 32 14 11 00b

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Task	Specification	Specification Description
32 14 11 00	31 25 14 23	Unit Pavers
32 14 13 19	03 31 13 00	Cement Concrete Pavement
32 14 16 00	32 14 11 00	Asphalt Concrete Sidewalks
32 14 16 00	32 14 11 00a	Miscellaneous Sidewalks
32 14 16 00	32 14 11 00b	Precast Sidewalks And Pavers
32 14 16 00	31 25 14 23	Unit Pavers

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## SECTION 32 14 33 13 - POROUS UNIT PAVING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for porous unit paving. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Porous paving consisting of concrete pavers set in aggregate setting beds.
  - b. Edge restraints.
  - c. Cast-in-place concrete edge restraints.
  - d. Precast concrete curbs.
  - e. Granite curbs.

#### C. Submittals

1. Product Data: For materials other than aggregates.
2. Sieve Analyses: For aggregate materials, according to ASTM C 136.
3. Samples:
  - a. Full-size units of each type of unit paver indicated.
  - b. Exposed edge restraints.
  - c. Precast concrete curbs.
  - d. Granite curbs.
  - e. Aggregate fill.
4. Material Certificates: For unit pavers. Include statements of material properties indicating compliance with requirements, including compliance with standards. Provide for each type and size of unit.

#### D. Quality Assurance

1. Preinstallation Conference: Conduct conference at Project site.

#### E. Delivery, Storage, And Handling

1. Store pavers on elevated platforms in a dry location. If units are not stored in an enclosed location, cover tops and sides of stacks with waterproof sheeting, securely tied.
2. Store aggregates where grading and other required characteristics can be maintained and contamination can be avoided.

### 1.2 PRODUCTS

#### A. Concrete Unit Pavers

1. Concrete Grid Pavers: Grid paving units complying with ASTM C 1319, made from normal-weight aggregates.
2. Solid Concrete Pavers for Porous Paving: Solid interlocking paving units of shapes that provide openings between units, complying with ASTM C 936, resistant to freezing and thawing when tested according to ASTM C 67, **as directed**, and made from normal-weight aggregates.
  - a. Thickness: **2-3/8 inches (60 mm) OR 3-1/8 inches (80 mm) OR 3-1/2 inches (90 mm) OR 4 inches (100 mm), as directed.**
  - b. Face Size and Shape: As indicated.
  - c. Color: As indicated by manufacturer's designations **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.





## B. Accessories

1. Plastic Edge Restraints: Triangular PVC extrusions, 1-3/4 inches (45 mm) high by 3-1/2 inches (90mm) wide **OR** 3-1/8 inches (80 mm) high by 9-1/2 inches (240 mm) wide, **as directed**, designed to serve as edge restraints for unit pavers; rigid type for straight edges and flexible type for curved edges, with pipe connectors and 3/8-inch- (9.5-mm-) diameter by 12-inch- (300-mm-) long steel spikes.
2. Steel Edge Restraints: Painted steel edging, 3/16 inch (4.8 mm) thick by 4 inches (100 mm) high **OR** 1/4 inch (6.4 mm) thick by 5 inches (125 mm) high, **as directed**, with loops pressed from or welded to face to receive stakes at 36 inches (900 mm) o.c., and with steel stakes 15 inches (380 mm) long for each loop.
  - a. Color: As indicated by manufacturer's designations **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.
3. Aluminum Edge Restraints: Straight, 1/8-inch- (3.2-mm-) thick by 4-inch- (100-mm-) high **OR** Straight, 3/16-inch- (4.8-mm-) thick by 4-inch- (100-mm-) high **OR** L-shaped, 1/8-inch- (3.2-mm-) thick by 1-3/8-inch- (35-mm-) high **OR** L-shaped, 3/16-inch- (4.8-mm-) thick by 2-1/4-inch- (57-mm-) high, **as directed**, extruded-aluminum edging, with loops pressed from face to receive stakes at 12 inches (300 mm) o.c., and with aluminum stakes 12 inches (300 mm) long for each loop.
4. Precast Concrete Curbs: Made from normal-weight concrete with a compressive strength not less than 5000 psi (35 MPa) **OR** 6000 psi (41 MPa), **as directed**, and water absorption not more than 5 percent, in shapes and sizes indicated.
  - a. Color and Texture: As indicated by manufacturer's designations **OR** Match the Owner's sample **OR** As selected by the Owner from manufacturer's full range, **as directed**.
5. Granite Curbs: Granite curbing, with face battered 1 inch per foot (1:12), produced in random lengths not less than 36 inches (900 mm) from granite complying with ASTM C 615.
  - a. Granite Color and Grain: Light gray **OR** Dark gray **OR** Buff **OR** White **OR** Black **OR** Pink, **as directed**, with fine **OR** medium **OR** coarse, **as directed**, grain.
  - b. Top Width: 4 inches (100 mm) **OR** 5 inches (125 mm) **OR** 6 inches (150 mm), **as directed**.
  - c. Face Height: 4 inches (100 mm) **OR** 6 inches (150 mm) **OR** 8 inches (200 mm), **as directed**.
  - d. Total Height: 12 inches (300 mm) **OR** 16 inches (400 mm) **OR** 18 inches (450 mm), **as directed**.
  - e. Top Finish: Sawed **OR** Thermal **OR** Bushhammered, **as directed**.
  - f. Face Finish: Split **OR** Sawed **OR** Thermal **OR** Bushhammered, **as directed**.

## C. Aggregate Setting-Bed Materials

1. Graded Aggregate for Subbase: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 57 **OR** ASTM D 448 for Size No. 5 **OR** ASTM D 2940, subbase material **OR** requirements in Division 31 Section "Earth Moving" for subbase material, **as directed**.
2. Graded Aggregate for Base Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** ASTM D 448 for Size No. 57 **OR** ASTM D 2940, base-course material **OR** requirements in Division 31 Section "Earth Moving" for base-course material, **as directed**.
3. Sand for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.
4. Soil Mix for Leveling Course: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate blended with planting soil mix complying with requirements in Division 32 Section(s) "Turf And Grasses" **OR** "Plants", **as directed**. Use blend consisting of 1/2 sand and 1/2 soil mix **OR** 2/3 sand and 1/3 soil mix, **as directed**.
5. Graded Aggregate for Leveling Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** 9, **as directed**.
6. Soil for Porous Paver Fill: Planting soil mix complying with requirements in Division 32 Section(s) "Turf And Grasses" **OR** "Plants", **as directed**.

7. Graded Aggregate for Porous Paver Fill: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** 9, **as directed**.
  - a. Provide stone of color indicated **OR** to match the Owner's sample, **as directed**.
8. Grass Seed: Comply with requirements in Division 32 Section "Turf And Grasses".
9. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications; made from polyolefins or polyesters, with elongation less than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
  - a. Survivability: Class 2; AASHTO M 288.
  - b. Apparent Opening Size: **No. 60 (0.250-mm)** sieve, maximum; ASTM D 4751.
  - c. Permittivity: 0.02 per second, minimum; ASTM D 4491.
  - d. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.
10. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent; complying with AASHTO M 288 and the following, measured per test methods referenced:
  - a. Survivability: Class 2; AASHTO M 288.
  - b. Apparent Opening Size: **No. 40 (0.425-mm)** sieve, maximum; ASTM D 4751.
  - c. Permittivity: 0.5 per second, minimum; ASTM D 4491.
  - d. UV Stability: 50 percent after 500 hours' exposure; ASTM D 4355.

### 1.3 EXECUTION

#### A. Preparation

1. Proof-roll prepared subgrade according to requirements in Division 31 Section "Earth Moving" to identify soft pockets and areas of excess yielding. Proceed with porous paver installation only after deficient subgrades have been corrected and are ready to receive subbase and base **OR** base, **as directed**, course for porous paving.

#### B. Installation, General

1. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be structurally unsound or visible in finished work.
2. Cut unit pavers with motor-driven masonry saw equipment or a block splitter, **as directed**, to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.
3. Tolerances:
  - a. Variation in Plane between Adjacent Units (Lipping): Do not exceed **1/16-inch (1.5-mm)** unit-to-unit offset from flush.
  - b. Variation from Level or Indicated Slope: Do not exceed **1/8 inch in 24 inches (3 mm in 600 mm)** and **1/4 inch in 10 feet (6 mm in 3 m)** or a maximum of **1/2 inch (13 mm)**.
4. Provide edge restraints as indicated. Install edge restraints before placing unit pavers.
  - a. Install edge restraints to comply with manufacturer's written instructions. Install stakes at intervals required to hold edge restraints in place during and after porous paver installation.
  - b. For metal edge restraints with top edge exposed, drive stakes at least **1 inch (25 mm)** below top edge.
  - c. Install job-built concrete edge restraints to comply with requirements in Division 32 Section "Concrete Paving".
5. Provide curbs as indicated. Install curbs before placing unit pavers.
  - a. Install precast concrete **OR** granite, **as directed**, curbs on a bedding of compacted base-course material over compacted subgrade. Install curbs before placing base course for pavers. Set curbs at elevations indicated, accurately aligned, and place and compact base-course material behind curbs as indicated.
  - b. Install precast concrete curbs on aggregate base course after placing and compacting base course for pavers. Set curbs with top edge **1 inch (25 mm)** below top of pavers. Anchor curbs with metal stakes driven through holes in curbs into base-course material.

- c. Install precast concrete curbs on aggregate-base course after placing and compacting base course for pavers. Set curbs with top surface **1/2 inch (13 mm) OR 2 inches (50 mm) OR 4 inches (100 mm), as directed**, above top of pavers. Anchor curbs with metal stakes driven behind curbs into base-course material.

#### C. Setting-Bed Installation

1. Compact soil subgrade uniformly to at least 95 percent of ASTM D 698 **OR** ASTM D 1557, **as directed**, laboratory density.
2. Proof-roll prepared subgrade to identify soft pockets and areas of excess yielding. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by the Owner, and replace with compacted backfill or fill as directed.
3. Place separation **OR** drainage, **as directed**, geotextile over prepared subgrade, overlapping ends and edges at least **12 inches (300 mm)**.
4. For light-traffic uses, place aggregate subbase **OR** subbase and base, **as directed**, compact by tamping with plate vibrator, and screed to depth indicated.
5. For heavy-duty applications, place aggregate subbase **OR** subbase and base, **as directed**, compact to 100 percent of ASTM D 1557 maximum laboratory density, and screed to depth indicated.
6. Place drainage geotextile over compacted subbase, overlapping ends and edges at least **12 inches (300 mm)**.
7. Place drainage geotextile over compacted base course, overlapping ends and edges at least **12 inches (300 mm)**.
8. Place leveling course and screed to a thickness of **1 to 1-1/2 inches (25 to 38 mm) OR 2 to 2-1/2 inches (50 to 64 mm) OR 3 inches (76 mm), as directed**, taking care that moisture content remains constant and density is loose and constant until pavers are set and compacted.

#### D. Paver Installation

1. Set unit pavers on leveling course, being careful not to disturb leveling base. If pavers have lugs or spacer bars to control spacing, place pavers hand tight against lugs or spacer bars. If pavers do not have lugs or spacer bars, place pavers with a **1/16-inch- (1.6-mm-) minimum and 1/8-inch- (3.2-mm-) maximum joint width**. Use string lines to keep straight lines. Fill gaps between units that exceed **3/8 inch (10 mm)** with pieces cut to fit from full-size pavers.
  - a. When installation is performed with mechanical equipment, use only unit pavers with lugs or spacer bars on sides of each unit.
2. Compact pavers into leveling course with a low-amplitude plate vibrator capable of a **3500- to 5000-lbf (16- to 22-kN)** compaction force at 80 to 90 Hz. Use vibrator with neoprene mat on face of plate or other means as needed to prevent cracking and chipping of pavers. Perform at least three passes across paving with vibrator.
  - a. Compact pavers when there is sufficient surface to accommodate operation of vibrator, leaving at least **36 inches (900 mm)** of uncompacted pavers adjacent to temporary edges.
  - b. Before ending each day's work, compact installed concrete pavers except for **36-inch (900 mm)** width of uncompacted pavers adjacent to temporary edges (laying faces).
  - c. As work progresses to perimeter of installation, compact installed pavers that are adjacent to permanent edges unless they are within **36 inches (90 mm)** of laying face.
  - d. Before ending each day's work and when rain interrupts work, cover pavers that have not been compacted and leveling course on which pavers have not been placed with nonstaining plastic sheets to protect them from rain.
3. Place soil fill as follows, immediately after vibrating pavers into leveling course. Spread and screed soil fill level with tops of pavers. Vibrate pavers and add soil fill until porous paving is filled to about **3/4 inch (19 mm)** from top surface; remove excess soil fill if any.
  - a. Before ending each day's work, place soil fill in installed porous paving except for **42-inch (1067-mm)** width of unfilled paving adjacent to temporary edges (laying faces).
  - b. As work progresses to perimeter of installation, place soil fill in installed paving that is adjacent to permanent edges unless it is within **42 inches (1067 mm)** of laying face.

- c. Before ending each day's work and when rain interrupts work, cover paving that has not been filled with nonstaining plastic sheets to protect it from rain.
  4. After filling pavers with soil, sow seed to comply with requirements in Division 32 Section "Turf And Grasses". except sow seed at half the rate specified for seeding lawns. Sweep seed from surfaces of pavers into voids and water with fine spray.
    - a. Within 24 hours after sowing seed, spread an additional **3/16 inch (4.8 mm)** of soil fill over seed and soak with water.
  5. Place graded aggregate fill immediately after vibrating pavers into leveling course. Spread and screed aggregate fill level with tops of pavers.
    - a. Before ending each day's work, place aggregate fill in installed porous paving except for **42-inch (1067-mm)** width of unfilled paving adjacent to temporary edges (laying faces).
    - b. As work progresses to perimeter of installation, place aggregate fill in installed paving that is adjacent to permanent edges unless it is within **42 inches (1067 mm)** of laying face.
    - c. Before ending each day's work and when rain interrupts work, cover paving that has not been filled with nonstaining plastic sheets to protect it from rain.
  6. Remove and replace pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.
- E. Maintenance And Protection
  1. Water newly planted grass and keep moist until grass is established. Maintain grass that is planted in paving to comply with requirements in Division 32 Section "Turf And Grasses".
  2. Erect barricades and warning signs as required to protect newly planted areas from traffic. Maintain barricades for 60 days after planting.

END OF SECTION 32 14 33 13

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Task	Specification	Specification Description
32 14 33 13	10 14 00 00	Vitrified Brick Pavement Replacement
32 15 40 00	32 11 16 16	Crushed Stone Paving
32 15 40 00	32 11 16 16a	Crushed Stone
32 15 40 00	32 11 16 16b	Select Gravel

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## SECTION 32 16 13 13 - STEEL CURBS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of steel curbs. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Standard Steel Curb Sections: Noncorrosive steel sections as required to match existing.

#### B. Coating: Steel curb sections shall be zinc coated.

#### C. Joint Materials

1. Expansion Joint Fillers: ASTM D 1751 or ASTM D 1752.
2. Joint Sealers: ASTM D 1850.

#### D. Concrete: Concrete shall have a minimum compressive strength of 3,000 psi. The maximum size of aggregate shall be 1-1/2 inches. Concrete shall have a slump of not more than 3 inches and an air content by volume of concrete of 3 to 6 percent.

### 1.3 EXECUTION

#### A. Preparation: The subgrade shall be constructed to grade and cross section. The subgrade shall be of materials equal in bearing quality to the subgrade under the adjacent pavement and shall be compacted. The subgrade shall be maintained in a smooth, compacted condition, in conformity with the required section and established grade until the concrete is placed. The subgrade shall be in a moist condition when concrete is placed.

#### B. Installation

1. Steel Curb Setting: Steel curbs shall be carefully set to alignment and grade and to conform to the dimensions of the curb.
2. Concrete Placement And Finishing: Concrete shall be placed in layers not to exceed 6 inches. Concrete shall be thoroughly consolidated. Floated surfaces shall then be brushed with longitudinal strokes. The top surface of the entrance shall be finished to grade with a wood float. Expansion joints and contraction joints shall be constructed at right angles to the line of curb. Contraction joints shall be constructed by means of 1/8-inch thick separators, of a section conforming to the cross section of the curb and gutter. Contraction joints shall match joints in abutting Portland cement concrete pavement. At other pavements, construction joints shall be placed at not less than 5 feet nor greater than 15 feet apart. Expansion joints shall be formed by means of preformed expansion joint filler material cut and shaped to the cross section of curb. Expansion joints shall be provided in curb at the end of all returns. Expansion joints shall match expansion joints of abutting Portland cement concrete pavement. At other pavements, expansion joints at least 1/2 inch in width shall be provided at intervals not exceeding 45 feet. Exposed concrete surfaces shall be cured for not less than 7 days.





3. Backfilling: After curing, debris shall be removed and the area adjoining the concrete shall be backfilled, graded, and compacted.
4. Sealing Joints: Expansion joints and the top 1-inch depth of contraction joints shall be sealed with joint sealer. The joint opening shall be thoroughly cleaned before the sealing material is placed. Excess material on exposed surfaces of the concrete shall be removed immediately and exposed concrete surfaces cleaned.

END OF SECTION 32 16 13 13

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Task	Specification	Specification Description
32 16 13 13	03 31 13 00	Cement Concrete Pavement
32 16 13 14	03 31 13 00	Cement Concrete Pavement
32 16 13 14	32 16 13 13	Steel Curbs
32 16 13 16	03 31 13 00	Cement Concrete Pavement
32 16 13 16	32 16 13 13	Steel Curbs
32 16 13 19	03 31 13 00	Cement Concrete Pavement
32 16 13 23	03 31 13 00	Cement Concrete Pavement
32 16 13 23	32 16 13 13	Steel Curbs
32 16 13 33	03 31 13 00	Cement Concrete Pavement
32 16 13 33	32 16 13 13	Steel Curbs
32 16 13 43	32 14 33 13	Porous Unit Paving
32 16 23 00	32 14 11 00	Asphalt Concrete Sidewalks
32 16 23 00	32 14 11 00a	Miscellaneous Sidewalks
32 16 23 00	32 14 11 00b	Precast Sidewalks And Pavers
32 16 23 00	31 25 14 23	Unit Pavers
32 16 43 00	32 01 13 61	Asphalt Paving
32 17 13 23	11 12 16 00	Parking Control Equipment
32 17 13 23	11 12 16 00a	Prefabricated Control Booths
32 17 13 26	11 12 16 00	Parking Control Equipment
32 17 13 26	11 12 16 00a	Prefabricated Control Booths
32 17 16 00	32 01 13 61	Asphalt Paving
32 17 23 13	32 01 13 61	Asphalt Paving
32 17 23 13	03 31 13 00	Cement Concrete Pavement
32 17 23 13	32 01 11 53	Traffic Coatings
32 17 23 23	32 01 13 61	Asphalt Paving
32 17 23 23	03 31 13 00	Cement Concrete Pavement
32 17 23 23	32 01 11 53	Traffic Coatings
32 17 23 33	32 01 13 61	Asphalt Paving
32 17 23 33	03 31 13 00	Cement Concrete Pavement
32 17 23 33	32 01 11 53	Traffic Coatings

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## SECTION 32 17 26 00 - TACTILE/DETECTABLE WARNING TILE

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for tactile/detectable warning tile. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product data for each specified product.
2. Shop drawings, showing detailed plans of tile profile, fastener locations, and installation methods
3. Two (2) tile samples, minimum size 6" x 8" of the kind proposed for use.
4. Material Test Reports: Submit test reports from qualified independent testing laboratory indicating that materials proposed for use are in compliance with requirements and meet the properties indicated. All test reports shall be conducted on a cast-in-place tactile panel system as certified by a qualified independent testing laboratory.
5. Maintenance Instructions: Submit copies of manufacturer's specified maintenance practices for each type of tactile tile and accessory as required.

#### C. Quality Control

1. Americans with Disabilities Act (ADA): Provide tactile warning surfaces, which comply with the detectable warnings on walking surfaces, section of the Americans with Disabilities Act (Title 49 CFR TRANSPORTATION, PART 37.9 STANDARDS FOR ACCESSIBLE TRANSPORTATION FACILITIES, Appendix A, Section 4.29.2 DETECTABLE WARNINGS ON WALKING SURFACES.
2. California Code of Regulations (CCR): Provide only approved DSAAC detectable warning products as provided in the California Code of Regulations (CCR). Title 24, Part 1, Articles 2, 3 and 4 and Part 2, Section 205 definition of "Detectable Warning". Section 1127B.5 for "Curb Ramps" and Section 1133B.8.5 for "Detectable Warnings at Hazardous Vehicle Area's".
3. Performance: Tiles shall meet or exceed the following criteria:
  - a. Water Absorption: 0.35% maximum, when tested in accordance with ASTM D570.
  - b. Slip Resistance: 0.90 minimum combined wet/ dry static coefficient of friction on top of domes and field area, when tested in accordance with ASTM C1028.
  - c. Compressive Strength: 18,000 psi minimum, when tested in accordance with ASTM D695.
  - d. Tensile Strength: 10,000 psi minimum, when tested in accordance with ASTM D638.
  - e. Flexural Strength: 24,000 psi minimum, when tested in accordance with ASTM C293.
  - f. Gardner Impact: 450 inch-pounds per inch minimum, when tested in accordance with Geometry "GE" of ASTM D5420.
  - g. Chemical Stain Resistance: No reaction to 1% hydrochloric acid, urine, calcium chloride, stamp pad ink, gum and red aerosol paint, when tested in accordance with ASTM D543.
  - h. Wear Depth: 0.03" maximum, after 1000 abrasion cycles of 40 grit Norton Metallite sandpaper, when tested in accordance with ASTM D2486-Modified.
  - i. Flame Spread: 25 maximum, when tested in accordance with ASTM E84.
  - j. Accelerated Weathering: No deterioration, fading or chalking for 2000 hours, when tested in accordance with ASTM D2565.
4. Tactile warning tiles embedded in or adhered to concrete shall meet or exceed the following performance criteria:
  - a. Accelerated Aging and Freeze Thaw of Adhesive System: No cracking, delamination, warping, checking, blistering, color change, loosening, etc. when tested in accordance with ASTM D1037.
  - b. Salt and Spray Performance: No deterioration after 100 hours of exposure, when tested in accordance with ASTM B117.

- D. Delivery, Storage And Handling
  - 1. Tiles shall be suitably packaged or crated to prevent damage in shipment or handling. Finished surfaces shall be protected by sturdy wrappings, and tile type shall be identified by part number.
  - 2. Tiles shall be delivered to location at building site for storage prior to installation.
- E. Warranty
  - 1. Installed tiles shall be warranted for a minimum of five (5) years against failure of adhesives, fasteners and sealants.

## 1.2 PRODUCT

- A. Materials
  - 1. Vitrified Polymer Composite (VPC) tiles shall be an epoxy polymer composition with an ultra violet stabilized coating employing aluminum oxide particles in the truncated domes. The tile shall incorporate an in-line dome pattern of truncated domes. For wheelchair safety the field area shall consist of a non-slip surface with a minimum of 40 - 90° raised points 0.045" high, per square inch.
  - 2. Color: Safety Yellow, (Federal Color # 33538) colorfast, UV stabilized coating. Color shall be homogeneous throughout the tile.
- B. Cast-In-Place Tactile Tile
  - 1. Tile shall be minimum 1-3/8" thick, with minimum 3/8" thick face and ribs designed for after-pour embedment in concrete.
- C. Surface Applied Detectable Warning Surface Tile
  - 1. The tile shall have with countersunk fastening holes and perimeter beveled edges.
  - 2. Accessories:
    - a. Fasteners: Color matched, corrosion resistant, flat head drive anchor, 1/4" diameter x 1-3/4" long.
    - b. Adhesive: Urethane elastomeric adhesive.
    - c. Sealants: Epoxy two component sealant.
- D. Modular Paver Tactile Tile
  - 1. Pre-cast with a 1-3/8" thick reinforced epoxy polymer concrete core.
    - a. Polymer Concrete and/or epoxy resin properties shall meet or exceed the following criteria:
 

Tensile Strength of Resin:	greater than 7,000psi; ASTM D638
Modulus of Elasticity of Resin:	greater than 4,000psi; ASTM D638
Bond Strength of Polymeric Concrete:	greater than 8,000psi; ASTM C551
  - 2. Accessories:
    - a. Adhesive: Urethane elastomeric adhesive.
    - b. Backer Rod: ASTM C 1330, Type C (closed-cell material with a surface skin) **OR** Type O (open-cell material) **OR** Type B (bicellular material with a surface skin), **as directed**, as approved in writing by joint-sealant manufacturer for joint application indicated, and of size and density to control sealant depth and otherwise contribute to producing optimum sealant performance
- E. Surface Applied Detectable Guidance Tiles
  - 1. Accessories:
    - a. Adhesive: Heavy-duty polyurethane elastomeric adhesive.
    - b. Sealants: Heavy-duty polyurethane elastomeric sealant.
- F. Surface Applied Detectable Directional Bar Tiles
  - 1. Accessories:
    - a. Fasteners: Stainless steel low profile expansion anchors, 3/16" diameter by 2" long.

- b. Adhesive: Heavy-duty polyurethane elastomeric adhesive.
- c. Sealants: Heavy-duty polyurethane elastomeric sealant.

1.3 EXECUTION

A. Installation

- 1. Installation shall be in strict compliance with manufacturer's printed instructions.

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## SECTION 32 18 16 13 - PLAYGROUND SURFACE SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for playground surface systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Unitary synthetic seamless surface.
  - b. Synthetic, dual-density tile surface.
  - c. Organic loose-fill surface.
  - d. Inorganic loose-fill surface.

#### C. Definitions

1. Critical Height: Standard measure of shock attenuation. According to CPSC No. 325, this means "the fall height below which a life-threatening head injury would not be expected to occur."
2. SBR: Styrene-butadiene rubber.

#### D. Performance Requirements

1. Impact Attenuation: According to ASTM F 1292.
2. Accessibility of Surface Systems: According to ASTM F 1951.
3. Minimum Characteristics for Organic Loose-Fill Surfaces: According to ASTM F 2075.

#### E. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: Show the following:
  - a. Installation details for curbs, ramps, and accessories.
  - b. Colors and pattern of surfaces.
  - c. Location of wear mats in organic loose-fill surfaces.
  - d. Location of drainage accessories.
3. Samples: For each type of playground surface system indicated.
  - a. Minimum 1-quart (0.95-L) loose-fill surface sealed in a container.
  - b. Minimum 6-by-6-inch- (150-by-150-mm-) square Sample of unitary synthetic seamless **OR** synthetic tile **OR** synthetic, dual-density, tile, **as directed**, surface.
  - c. 6-inch (150-mm) long by full-size cross section of border edging.
  - d. Minimum 12-by-12-inch (300-by-300-mm) Sample of geosynthetic fabric.
  - e. Minimum 6-by-6-inch (150-by-150-mm) Sample of geosynthetic, molded-sheet drainage panel.
4. Qualification Data: For Installer and testing agency.
5. Material Test Reports: For the following, from a qualified testing agency, indicating compliance with requirements:
  - a. Unitary synthetic seamless surface.
  - b. Synthetic tile surface.
  - c. Organic loose-fill surface.
  - d. Inorganic loose-fill surface.
6. Material Certificates: For each playground surface system product, signed by manufacturers.
7. Field quality-control test reports.
8. Maintenance Data: For playground surface system to include in maintenance manuals.
9. Warranty: Special warranty specified in this Section.

#### F. Quality Assurance





1. Installer Qualifications: An employer of workers trained and approved by manufacturer.
2. Testing Agency Qualifications: An independent agency qualified according to ANSI Z34.1 for testing indicated.
3. Source Limitations: Obtain playground surface system materials, including primers and binders, through one source from a single manufacturer.
  - a. Provide secondary materials including adhesives, primers, geosynthetics, and repair materials of type and from source recommended by manufacturer of playground surface system materials.

G. Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of playground surface system that fail in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
  - a. Reduction in impact attenuation.
  - b. Deterioration of surface and other materials beyond normal weathering.
2. Warranty Period: Three **OR** Five **OR** 10, **as directed**, years from date of Final Completion.

## 1.2 PRODUCTS

### A. Unitary Synthetic Seamless Surface

1. Surface System: Poured-in-place, single-layer system. Provide manufacturer's standard thickness as required for overall thickness indicated, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
  - a. Cushion Course: Manufacturer's standard blend of recycled SBR and EPDM rubber, particles forming an integral wearing course and cushion course, site mixed and applied.
  - b. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane complying with requirements of authorities having jurisdiction for nontoxic and low VOC content.
  - c. Critical Height: **3 feet (1 m) OR 4 feet (1.2 m) OR 5 feet (1.5 m) OR 6 feet (1.8 m) OR 7 feet (2.1 m) OR 8 feet (2.4 m) OR 9 feet (2.7 m) OR 10 feet (3 m) OR 12 feet (3.7 m), as directed.**
  - d. Overall Thickness: Not less than as required for critical height indicated **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 2-1/2 inches (64 mm) OR 3 inches (75 mm) OR 3-1/2 inches (89 mm) OR 4 inches (100 mm), as directed.**
  - e. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location indicated.
  - f. Color(s): As selected from manufacturer's full range.
2. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.

### B. Unitary Synthetic Dual-Density Seamless Surface

1. Surface System: Poured-in-place, two-layer system with wearing course over cushion course. Provide manufacturer's standard thickness for each layer as required for overall thickness indicated, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
  - a. Wearing Course: Formulation of EPDM rubber particles, with minimum of 20 percent and maximum of 26 percent of ethylene propylene-diene-saturated polymethylene main chain along with other organic and inorganic components.
  - b. Cushion Course: Manufacturer's standard formulation of recycled SBR particles and polyurethane, site mixed and applied.
  - c. Binder: Weather-resistant, UV-stabilized, flexible, nonhardening, 100 percent solids polyurethane complying with requirements of authorities having jurisdiction for nontoxic and low VOC content.
  - d. Lacquer Top Coat: Manufacturer's standard polyurethane-based formulation.

- e. Critical Height: **3 feet (1 m) OR [4 feet (1.2 m) OR 5 feet (1.5 m) OR 6 feet (1.8 m) OR 7 feet (2.1 m) OR 8 feet (2.4 m) OR 9 feet (2.7 m) OR 10 feet (3 m) OR 12 feet (3.7 m), as directed.**
  - f. Overall Thickness: Not less than as required for critical height indicated **1-1/2 inches (38 mm) OR 2 inches (50 mm) OR 2-1/2 inches (64 mm) OR 3 inches (75 mm) OR 3-1/2 inches (89 mm) OR 4 inches (100 mm) OR 4-1/2 inches (114 mm) OR 5 inches (125 mm) OR 5-1/2 inches (140 mm), as directed.**
  - g. Primer/Adhesive: Manufacturer's standard primer and weather-resistant, moisture-cured polyurethane adhesive suitable for unit, substrate, and location indicated.
  - h. Wearing Course Color(s): As selected from manufacturer's full range.
    - 1) Color **Pattern OR Graphics**: As directed.
  2. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.
- C. Unitary Synthetic Tile Surface
1. Tile System: Manufacturer's standard blend of recycled SBR, EPDM rubber, or PVC particles forming an integral wearing course and cushion course, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
    - a. Unit Size: **24 by 24 inches (600 by 600 mm).**
    - b. Base Profile: With integral ribbed or grid-patterned underside forming channels for water drainage between surface and substrate.
    - c. Border Edge and Corner Units: Tapered, bevel-edged units that transition from the face of playground surface to the adjacent surface below it with a straight-sloped outside edge; size compatible with field units maintaining layout pattern continuity. Provide border edge and corner units where surface does not abut vertical surfaces.
    - d. Critical Height: **7 feet (2.1 m) OR 12 feet (3.7 m), as directed.**
    - e. Overall Thickness: Not less than as required for critical height indicated **1-3/4 inches (45 mm) OR 2-3/4 inches (70 mm) OR 4 inches (100 mm), as directed.**
    - f. Anchors: Manufacturer's standard.
    - g. Anchor Cement: Manufacturer's standard nonshrink grout or polymer resin.
    - h. Tile Color(s): **As directed.**
      - 1) Color **Pattern OR Graphics**: As selected from manufacturer's full range.
    - i. Filler/Sealant: Manufacturer's standard clear silicone or polyurethane filler/sealant suitable for exterior use.
  2. Leveling and Patching Material: Portland cement-based grout or epoxy- or polyurethane-based formulation suitable for exterior use and approved by playground surface system manufacturer.
- D. Organic Loose-Fill Surface
1. Wood Chips: Random-sized wood chips suitable for mulching trees and shrubs.
  2. Double-Shredded Bark Mulch: Random-sized bark, shredded twice, suitable for mulching trees and shrubs.
  3. Engineered Wood Fibers: Random-sized wood fibers, in manufacturer's standard fiber size, approximately 10 times longer than wide; containing no bark, leaves, twigs, or foreign or toxic materials according to ASTM F 2075; graded according to manufacturer's standard specification for material consistency for playground surfaces and for accessibility according to ASTM F 1951.
    - a. Critical Height: **6 feet (1.8 m) OR 9 feet (2.7 m) OR 10 feet (3 m) OR 11 feet (3.4 m), as directed.**
    - b. Uncompressed Material Depth: Not less than as required for critical height indicated **OR 6 inches (150 mm) OR 9 inches (229 mm) OR 12 inches (305 mm), as directed.**
- E. Inorganic Loose-Fill Surface
1. Inorganic Aggregate Materials: Clean, washed, and free of loam, clay, organic matter, debris, and other foreign substances.
    - a. Fine Sand: Complying with ASTM C 136 for the following sieve analysis test results; provide minimum depth of material with critical height indicated according to CPSC No. 325:



- 1) Sieve Sizes and Percent Passing through Screen: No. 16 passing 100 percent, No. 30 passing 98 percent, No. 50 passing 62 percent, No. 100 passing 17 percent, and No. 200 passing 0 to 1 percent.
  - b. Coarse Sand: Complying with ASTM C 136 for the following sieve analysis test results; provide minimum depth of material with critical height indicated according to CPSC No. 325:
    - 1) Sieve Sizes and Percent Passing through Screen: No. 4 passing 98 percent, No. 8 passing 73 percent, No. 16 passing 4 percent, No. 30 passing 1 percent, and No. 50 passing 0 to 1 percent.
  - c. Fine Gravel: Rounded, hard, durable stone, free of sand, with particle size less than **3/8 inch (9.5 mm)** in diameter complying with ASTM C 136 for the following sieve analysis test results; provide minimum depth of material with critical height indicated according to CPSC No. 325:
    - 1) Sieve Sizes and Percent Passing through Screen: **3/8 inch (9.5 mm)** passing 100 percent, No. 3-1/2 passing 93 percent, No. 4 passing 65 percent, No. 8 passing 8 percent, No. 16 passing 5 percent, and No. 30 passing 4 percent.
  - d. Medium Gravel: Rounded, hard, durable, riverbed gravel or tumbled stone, free of sand, with particle size less than **1/2 inch (13 mm)** in diameter complying with ASTM C 136 for the following sieve analysis test results; provide minimum depth of material with critical height indicated according to CPSC No. 325:
    - 1) Sieve Sizes and Percent Passing through Screen: **1/2 inch (13 mm)** passing 100 percent, **3/8 inch (9.5 mm)** passing 80 percent, **5/16 inch (8 mm)** passing 20 percent, No. 4 passing 8 percent, and No. 16 passing 3 percent.
  2. Shredded Tires: Rubber particles from 100 percent recycled tires, free from steel wires, rubber dust, and other foreign substances, tested for impact attenuation according to ASTM F 1292 and for accessibility according to ASTM F 1951.
    - a. Critical Height: **6 feet (1.8 m) OR 9 feet (2.7 m) OR 10 feet (3 m) OR 11 feet (3.4 m), as directed.**
    - b. Uncompressed Material Depth: Not less than as required for critical height indicated **OR 6 inches (150 mm) OR 9 inches (229 mm) OR 12 inches (305 mm), as directed.**
- F. Loose-Fill Accessories
1. Edgings: Anchored-in-place, weather-resistant containment barrier designed to minimize sharp edges, protrusions, and tripping hazards; formed by interconnected, modular units.
    - a. Polyethylene Units: UV-light-stabilized, 100 percent recycled polyethylene, not less than **1/4-inch (6 mm)** wall thickness; made into smooth-surfaced straight and curved units with radiused exposed edges and integral, molded-in color; in manufacturer's standard sizes.
      - 1) Color: As selected from manufacturer's full range.
    - b. Metal Units: Steel fabricated with radiused exposed edges and finished with PVC plastisol coating, straight **OR** right-angled corner, **as directed**, and curved units, in manufacturer's standard sizes.
      - 1) Color: As selected from manufacturer's full range.
    - c. Rubber Units: Compression molded from 100 percent recycled SBR, in manufacturer's standard sizes.
      - 1) Color: As selected from manufacturer's full range.
    - d. Anchor Stakes: Manufacturer's standard, of corrosion-resistant-coated metal or noncorrodible material, designed to be nonprotruding when installed, for connecting units and securing in-place.
  2. Stabilizing Mats: Manufacturer's standard, water-permeable PVC or rubber mats tested for impact attenuation according to ASTM F 1292, and rated for use in the following locations, with anchoring system designed to anchor mat securely to subgrade through engineered wood:
    - a. Location: At excessive wear areas and as follows:
      - 1) On top of loose-fill surface.
      - 2) Below top of loose-fill surface.
      - 3) On subgrade below loose-fill surface.

- 4) Under and in front of slide exits.
- 5) Under and around swings.
- 6) At finished grade around transfer stations at accessible perimeter.
- 7) At high-traffic areas and playground equipment where indicated.
- 8) Where indicated.
- b. Size: **36 by 36 inches (914 by 914 mm) OR 40 by 40 inches (1016 by 1016 mm) OR 48 by 48 inches (1200 by 1200 mm), as directed.**
- c. Color: As selected from manufacturer's full range.

G. Geosynthetics

1. Drainage/Separation Geotextile: Nonwoven, needle-punched geotextile, manufactured for subsurface drainage applications and made from polyolefins or polyesters; complying with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
  - a. Weight: **4 oz./sq. yd. (136 g/sq. m)** according to ASTM D 5261.
  - b. Water Flow Rate: **100 gpm/sq. ft. (68 L/s per sq. m) OR 150 gpm/sq. ft. (102 L/s per sq. m), as directed,** according to ASTM D 4491.
2. Molded-Sheet Drainage Panel: Prefabricated, composite drainage panels made with drainage core and filter fabric.
  - a. Drainage Core: Three-dimensional, nonbiodegradable, molded-plastic-sheet material designed to effectively drain water under maximum fill pressures.
  - b. Fabric: Nonwoven, needle-punched geotextile, specifically manufactured as a filter geotextile and made from polyolefins or polyesters; complying with the following minimum properties determined according to ASTM D 4759 and referenced standard test methods:
    - 1) Weight: **4 oz./sq. yd. (136 g/sq. m)** according to ASTM D 5261.
    - 2) Water Flow Rate: **100 gpm/sq. ft. (68 L/s per sq. m) OR 150 gpm/sq. ft. (102 L/s per sq. m), as directed,** according to ASTM D 4491.
  - c. Minimum Flow Rate: **9 gpm/foot (1.9 L/s per m)** according to ASTM D 4491.
3. Weed-Control Barrier: Composite fabric geotextile consisting of woven, needle-punched polypropylene substrate bonded to a nonwoven polypropylene fabric, weighing not less than 4.8 oz./sq. yd. (160 g/sq. m).

1.3 EXECUTION

A. Preparation

1. General: Prepare substrates to receive surfacing products according to playground surface system manufacturer's written instructions. Verify that substrates are sound and without high spots, ridges, holes, and depressions.
2. Concrete **OR** Asphalt, **as directed**, Substrates: Provide sound surface free of laitance, efflorescence, curing compounds, and other contaminants incompatible with playground surface system.
  - a. Repair unsatisfactory surfaces and fill holes and depressions.
  - b. Mechanically scarify or otherwise prepare concrete substrates to achieve recommended degree of roughness.
  - c. Saw cut concrete **OR** asphalt, **as directed**, for terminal edges of playground surface systems as indicated.
  - d. Treat control joints and other nonmoving substrate cracks to prevent telegraphing through playground surface system.

B. Installation, General

1. General: Comply with playground surface system manufacturer's written installation instructions. Install playground surface system over area and in thickness indicated.

C. Geosynthetic Installation



1. General: Install geosynthetics according to playground surface system manufacturer's and geosynthetic manufacturer's written instructions.
  - a. Geotextiles: Completely cover area indicated, overlapping sides and edges a minimum of **4 inches (100 mm) OR 8 inches (200 mm)**, **as directed**, with manufacturer's standard treatment for **OR** overlapping loosely laid **OR** adhesively bonded, **as directed**, seams.
    - 1) Perimeter: Adhere edges on all sides to top of perimeter curb or footing.
- D. Installation Of Seamless Playground Surface Systems
  1. Seamless Surface: Mix and apply components of playground surface system according to manufacturer's written instructions.
    - a. Substrate Primer: Apply over prepared substrate at manufacturer's standard spreading rate for type of substrate.
    - b. Cushion Course: Spread evenly over primed substrate to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation, with a minimum of cold joints.
    - c. Cushion Course: Lay out tile units from center marks established with principal perimeter edges, discounting minor offsets, so units at opposite edges of installation are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half of a unit at perimeter.
    - d. Intercoat Primer: Over cured cushion course, apply primer at manufacturer's standard spreading rate.
    - e. Wearing Course: Spread over primed base course to form a uniform layer applied at manufacturer's standard spreading rate in one continuous operation and, except where color changes, with no **OR** a minimum of, **as directed**, cold joints. Finish surface to produce manufacturer's standard wearing-surface texture.
      - 1) Where colored pattern is **OR** graphics are, **as directed**, indicated, place adjacent colored material as soon as placed colored material is sufficiently cured, using primer or adhesive if required by manufacturer's written instructions.
    - f. Edge Treatment: Flush **OR** Extended surface course **OR** Saw-cut base and vertical pour, **as directed**.
- E. Installation Of Tile Playground Surface Systems
  1. Tile Units: Provide a uniform wearing surface with no unaligned units, raised edges, or surface imperfections.
    - a. Lay out units from center marks established with principal perimeter edges, discounting minor offsets, so units at opposite edges of installation are of equal width. Adjust as necessary to avoid using cut widths that equal less than one-half of a unit at perimeter. Allow for border edge.
      - 1) Alignment Axis and Pattern: Lay units along axis and in grid pattern indicated.  
**OR**  
Alignment Axis: Lay units square **OR** at a 45-degree angle, **as directed**, with playground equipment axis.
      - 2) Pattern: Lay units in straight-line grid pattern with joints aligned.  
**OR**  
Pattern: Lay units in half-unit, offset grid pattern with staggered joints.
    - b. Cut and fit units around playground equipment supports and vertical surfaces. Do not create voids greater than **3/8 inch (9.5 mm)** wide.
      - 1) Do not stretch units during installation.
    - c. Adhesively Applied Units: Adhere units to substrates using a full spread of adhesive applied to substrate or to unit and to each other.
    - d. Mechanically Fastened Units: Anchor to substrates.
    - e. Mechanically Attached Units (only for solid revulcanized rubber units): Mechanically attach all four sides of units, including border edge and corner units, to each other using number of fasteners per side as recommended by system manufacturer. Free lay sheet of attached units on substrate.



- f. Mechanically Attached Units Retained by Adhesively Applied Perimeter Units: Mechanically attach all four sides of units to each other using number of fasteners per side as recommended by system manufacturer. Adhere not less than one course of perimeter units and border edge and corner units to substrates using a full spread of adhesive applied to substrate or to unit and to each other.
  - g. Edge Borders: Maintain fully cushioned thickness.
  - h. Filler/Sealant: Mask area surrounding cutouts around playground equipment supports and other obstructions. Apply a full bead of filler/sealant, filling cutouts immediately after laying tile with cutout.
- F. Installation Of Loose-Fill Playground Surface Systems
  - 1. Loose-Fill Edgings: Place as indicated, and permanently secure in place and attach to each other according to edging manufacturer's written instructions.
  - 2. Loose Fill: Place playground surface system materials including manufacturer's standard amount of excess material for compacting naturally with time **OR** including manufacturer's standard amount of excess material for compacting mechanically, **as directed**, to required depths after Installation of playground equipment support posts and foundations.
  - 3. Stabilizing Mats: Coordinate installation of mats and mat anchoring system with placing and compacting of loose-fill.
  - 4. Compacting and Grading: Uniformly compact and grade loose-fill according to manufacturer's written instructions to an even surface free from irregular surface changes as indicated.
  - 5. Finish Grading: Hand rake to a smooth finished surface and to required elevations.
- G. Field Quality Control
  - 1. Testing Services: Testing and inspecting of completed applications of playground surface system shall take place according to ASTM F 1292.
  - 2. Remove and replace applications of playground surface system where test results indicate that it does not comply with requirements.
  - 3. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with requirements.
- H. Protection
  - 1. Seamless **OR** Tile, **as directed**, Systems: Prevent traffic over system for not less than 48 hours after installation.

END OF SECTION 32 18 16 13

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## SECTION 32 18 16 13a - TRACK, COURT, AND PLAYGROUND MARKINGS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing of materials and the installation of track, court, and playground markings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Submit product data and manufacturer's recommendations for each marking to be furnished.
2. Submit sample of each marking to be furnished.
3. Submit "Line Layout Drawing" prior to installation of marking and upon completion of markings, submit three (3) certified line layout drawings indicating all lines and colors.

#### C. Quality Assurance: Personnel shall have a minimum of three years marking experience.

#### D. Delivery, Storage and Handling: Deliver paint to site in original sealed containers or drums, with labels legible, intact and unbroken. Comply with all health and fire regulations.

#### E. Environmental Requirements: Do not install markings on wet or frozen surfaces. Comply with manufacturer's instructions for temperature requirements.

### 1.2 PRODUCTS

#### A. Manufacturers

1. Line Paint for Resilient Surface: Aliphatic polyurethane paint, such as Hi-Build Aliphatic Polyurethane paint by Sherwin-Williams, or approved equivalent.
2. Line Paint for Asphaltic Concrete Pavement: Latex traffic marking paint, such as Setfast Latex Traffic Marking paint by Sherwin-Williams, or approved equivalent.
3. Line Paint for Athletic Wearing Surface (Plexipave): 100% acrylic latex paint, such as Plexicolor by California Products, or approved equivalent.

### 1.3 EXECUTION

#### A. Application

##### 1. Line Painting

- a. Accurately measure and layout line markings.
- b. Apply paint with mechanical equipment.
- c. Paint lines as specified below under "Track Marking".
- d. Provide uniform straight edges.
- e. Apply not less than two coats in accordance with manufacturer's recommended rates.
- f. Lines shall be 2 in. (50 mm) wide unless otherwise specified.

##### 2. Track Marking

- a. Employ a licensed land surveyor to accurately measure and lay out line markings in accordance with National Federation of State High School Athletic Association Regulations or other Standards set forth by the Owner.
- b. Events:
  - 1) 100 meter dash
  - 2) 200 meter dash
  - 3) 400 meter dash



- 4) 800 meter run
  - 5) 1600 meter run
  - 6) 3200 meter run
  - 7) One mile run
  - 8) 4 x 100 meter relay
  - 9) 4 x 200 meter relay
  - 10) 4 x 400 meter relay
  - 11) 4 x 800 meter relay
  - 12) 110 meter high hurdles
  - 13) 300 meter intermediate hurdles
  - 14) Girls 100 meter hurdles
  - 15) Girls 300 meter hurdles
  - c. Hurdle location markers: yellow hash marks.
  - d. Lane lines: white (min. 42 in. (105 cm) apart).
  - e. Exchange zones:
    - 1) 4 x100 m green
    - 2) 4 x 200 m blue
    - 3) 4 x 400 m yellow
    - 4) 12 in. (305 mm) across entire lane width.
  - f. Lane numbers: Stenciled in three locations from inside to outside. Numbers shall be 24 in. (60 cm) high and white in color.
  - g. Finish line to be located near bleachers.
  - h. All starts and finishes to be white.
- B. Cleaning: Upon completion of work, remove containers and debris and leave site in clean orderly condition acceptable to the Owner.
- C. Protection
1. Erect temporary barriers to protect paint during drying period.
  2. Protect markings from damage until completion of project.

END OF SECTION 32 18 16 13a

## SECTION 32 18 16 13b - SYNTHETIC RUNNING TRACK SURFACE

### 1.1 GENERAL

- A. Description Of Work
  - 1. This specification covers the furnishing and installation of synthetic running track surface. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.
- B. Submittals: Submit the following:
  - 1. Sample of the actual sport surface in the standard color(s) selected.
  - 2. Technical data sheets of the product.
  - 3. Adhesive product data sheets and manufacturer's certificate indicating approval for the proposed application.
  - 4. Line paint data sheets and the manufacturer's certificate indicating approval for the proposed application.
  - 5. Submit 3 copies of the maintenance instruction.
- C. Delivery and Storage: Deliver and store the material in the original packaging with the labels intact in a controlled environment of a minimum temperature of 55°F (13°C) and under 50% relative humidity. Protect work until accepted by the Owner.
- D. Warranty: Provide manufacturer's standard warranty.

### 1.2 PRODUCTS

- A. Acrylic Color Coating System
  - 1. Manufacturer: Copeland Coating Company or approved equivalent.
  - 2. System shall consist of stone base, asphalt binder/top, cushion made of granulated rubber particles suspended in acrylic emulsions (**as directed**), acrylic filler coat(s), acrylic finish coat, and acrylic line paint.
  - 3. Design and construction shall be by materials manufacturer.
- B. Polyurethane
  - 1. Manufacturer: Conica Sports Surfaces or approved equivalent.
  - 2. Impermeable, full polyurethane, 3 layer athletic track system. In-situ applied with a granular colored EPDM finish. IAAF certified as required.
- C. Rubber Granule Surface
  - 1. Manufacturer: Atlas Track & Tennis or approved equivalent.
  - 2. Rubber granules applied "dry" to the surface and adhered by spray application of a resin binder. This process is repeated until the specified thickness is achieved, allowing sufficient curing time between each application. The process is then finished with a structural spray coating of highly pigmented polyurethane coating.
- D. Prefabricated Rubber Surface
  - 1. Manufacturer: Mondo USA, or approved equivalent.
  - 2. Prefabricated rubber sport surface to be 6 mm (1/4") **OR** 8mm (5/16") **OR** 10mm (3/8") **OR** 12mm (1/2") **OR** 14mm (9/16"), **as directed**, thickness, with a non-slip, non-reflecting, highly spike resistant top surface. Provided in manufacturer's standard colors.
  - 3. Prefabricated rubber surface to be sheet goods, double durometer or homogenous vulcanized and calandered, with a particular closed cell structure, based on special isoprenic rubbers, mineral fillers, vulcanizing and stabilizing agents and color pigments, highly resistant to UV rays

and atmospherical agents, with system of differentiated elasticity between top surface and base, supplied in rolls of suitable size and thickness. Surface shall have a special texture including adhesive and striping

4. Prefabricated rubber sport surface to be manufactured in two layers, which are vulcanized together. The shore hardness of the lower layer to be less than the upper layer, shore hardness of the respected layers to be recommended by the manufacturer and within the limits hereinafter specified. Field laminated triple durometer are unacceptable.
5. Adhesive: Rubber sport surface adhesive to be two part polyurethane adhesive suitable for adherence of a sheet good to asphalt, concrete or urethane substrate. Adhesive to be supplied or approved/recommended by sport surface manufacturer.

E. Patching Compound: Patching compound to be supplied or approved/recommended by sport surface manufacturer.

F. Line marking: Line marking paint to be supplied by sport surface manufacturer.

### 1.3 EXECUTION

#### A. Installation

1. Install sport flooring in accordance with manufacturer's printed instructions.
2. Prefabricated sport flooring shall be unrolled and allowed to relax.
3. Cut and adjust prefabricated sport flooring prior to adhesion.
4. Mix adhesive in accordance with manufacturer's instructions.
5. Hold all seams in place with suitable weights for a minimum of 12 hours.
6. Lines to be painted as per manufacturer's recommendations.
7. Surface to be protected before, during and after installation until project's acceptance by the the Owner or his agent.

END OF SECTION 32 18 16 13b



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Task	Specification	Specification Description
32 18 16 13	11 66 13 00	Playground Equipment And Structures
32 18 16 13	11 68 13 00	Recreational Facilities

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## SECTION 32 18 23 29 - COLORED ATHLETIC WEARING SURFACE

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of colored athletic wearing surface on asphaltic concrete base. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

- B. Submittals: Submit product data and manufacturer's application instruction.

### 1.2 PRODUCTS

- A. Manufacturer: Athletic wearing surface shall be the "Plexipave" system by California Products Corporation, 169 Waverly Street, Cambridge Ma. 02139 or approved equal.
- B. Plexipave Court Patch Binder prepared as per manufacturers recommendations.
- C. California Acrylic Resurfacer prepared as per manufacturers recommendations.
- D. Fortified Plexipave Job Mix prepared as per manufacturers recommendations.
- E. Plexipave Color Base as required to meet project requirements.
- F. Plexichrome Color as required to meet project requirements.

### 1.3 EXECUTION:

- A. Personnel used to install athletic wearing surface must have a minimum of three years experience and at least three jobs with similar square footage of placement.
- B. When required, asphaltic concrete base shall be placed to conform to manufacturer's planarity requirements.
- C. Protect adjacent surfaces not to receive coating during application.
- D. All finished surfaces must have a uniform appearance and be free of ridges and tool marks and shall not vary more than 1/8" in 10 feet measured in any direction.

END OF SECTION 32 18 23 29

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## SECTION 32 18 23 29a - SYNTHETIC TURF

### 1.1 GENERAL

#### A. Description Of Work

1. This section covers the furnishing and/or installation of: synthetic turf with covers for cut-outs; paint lines and markings for football, soccer and baseball fields; the painting of a logo at midfield; line painter equipment, portable blower for ground clean-up, turf vacuum cleaner, and pylon markers. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals:

1. Turf covers for baseball infield cutouts.
2. Painting template for a logo.
3. Layouts for lines and markings of game fields.
4. Maintenance Manual: 2 copies, providing a full description of materials to be used for maintaining Synthetic Turf System.
5. Manufacturer's literature for line painter equipment, turf vacuum cleaner, and portable blowers.
6. Warranties: For synthetic turf, for line painter equipment, for turf vacuum cleaner, and for portable blowers.
7. Synthetic turf: Sample, technical data and manufacturer's directions for installation and maintenance.
8. Line Paint: Manufacturer's literature and application directions.

#### C. Warranties: The warranty submitted shall have the following characteristics:

1. Shall provide full coverage for eight (8) years, from date of first use.
2. Shall warrant materials and workmanship.
3. Shall warrant that the materials installed meet or exceed the product specifications.
4. Shall have a provision to either: (a) make repairs or (b) replace such portions of the installed materials that are no longer serviceable, to maintain a serviceable and playable surface, and make good without cost or expense to the Owner.
5. Shall state all limitations and exclusions.
6. Shall be a warranty from a single source covering workmanship and all self-manufactured or procured materials.
7. Warranty shall be for full value, not prorated.

### 1.2 PRODUCTS

#### A. Synthetic Turf

1. Synthetic turf shall be Astro Turf-8, by Astro Turf Industries, Inc., 809 Kenner Street, Dalton, Georgia 30720, or approved equivalent.
2. Turf fabric: Knitted of nylon 6.6 ribbon with a polyester filament backing yarns and weighing approximately 63 ounces per square yard.
3. Pile material: 500 denier, textured nylon, 6.6 ribbon with a 1/2-inch pile height to give the appearance of mown grass; weight 50 ounces per square yard; pigmented green and stabilized for outdoor exposure.
4. Backing Yarns: High strength polyester fiber yarns, heat set for maximum dimensional stability.

#### B. Underpad

1. Underpad: 5/8-inch thick, energy-absorbing, made of closed cell foam, reinforced with carbon black, and perforated for drainage.
2. Pad density: 7.5 pounds per cubic foot.
3. Compression module: 25%, 8 pounds per square inch.





4. Perforations: 3/8-inch holes, 3 on center in a staggered pattern, factory perforated.
- C. Adhesives for bonding the synthetic turf to the pad shall be weather-resistant to withstand the climate of the site and shall be compatible with the materials of the turf and pad.
- D. All butt seams of the turf surface shall be sewn and glued.
- E. Paint shall be Sherwin-Williams "Watch-Guard System Metalex" semi-gloss enamel, or approved equivalent.
- F. Line painter shall be Model 98-331, as manufactured by Binks Co., or approved equivalent, with 5 gallon pressure-tested tank, adjustable line marker, quick disconnect for ease of cleaning, 12" front pneumatic wheels, 5HP 4-cycle air-cooled gasoline engine, air-actuated spray gun, dual cylinder compressor.
- G. Turf vacuum cleaner shall be Model BT-80-VIC, manufactured by the Billy Goat Industries, Inc., Lees Summit, MO, or approved equivalent. Vacuum shall be 8 HP Push-gasoline Big Wheel model complete with 5" intake hose kit (Part No. 800521) exhaust hose kit (Part No. 800077), and caster assembly (Part No. 800065).
- H. Portable Blower for Ground Cleanup
  1. Windmill "Fast-Blo", Model No. 22B hand-held gas power blower as supplied by A.M. Leonard Inc., Piqua, Ohio, or approved equivalent.
  2. Variable speed control, 2-cycle gas engine type, weighing 10 pounds.
- I. Football Pylons: Model No. "WP-12"
  1. "Ethafoam", water and mildew resistant, size 4" x 4" x 18", of standard bright color.
  2. Weighted: Springs back upon impact.
  3. Provide two (2) sets of twelve (12) pylons for a total of 24, for football field.
- J. Soccer Flags
  1. Soccer Flags: Model "WSF" as manufactured by Marty Gilman, Inc., Gilman, CT. 06336, or approved equivalent.
  2. Provide two (2) sets of four (4) flags for a total of eight, for soccer field.
- K. Baseball Infield Conversion System
  1. Submit Shop Drawings indicating method of detailing conversion panels for approval.
  2. Panels shall be removable in conversion area.
  3. Cut panels from same synthetic turf material as football field, to match.
  4. Provide spacers and pad wedges.

### 1.3 EXECUTION

- A. Before any synthetic turf is installed, the Contractor shall inspect the asphaltic concrete base and, when satisfied with its condition, shall notify the Owner in writing of acceptance of the base.
- B. A manufacturer's representative shall be present at the job site when the synthetic turf is installed. Turf shall be laid in strict accordance with the manufacturer's instructions by workmen who are skilled in this type of work.
- C. Turf material shall be protected before, during and after installation.
- D. Installed work and materials of other trades shall be protected.

- E. Assurance
1. Qualified bidders must have successfully installed at least five (5) other outdoor installations of synthetic stadium surface within the last three (3) years of a type described herein.
  2. The field installation shall be made under the direct, active, personal supervision of technical representatives of the synthetic turf manufacturer. All key positions shall be manned by experienced employees of the installer.
  3. The synthetic turf contractor shall keep a full-time superintendent on the project during the installation of the synthetic turf.
  4. The synthetic turf system supplied shall be of previous acceptance at all levels of competition, including University and Professional.
- F. Underpad Installation
1. At "float drain" system: strip glue underpad at all joints.
  2. At "vertical drain" system: provide intermittent gluing at a spread rate of 150-160 sq. ft./gal.
  3. Sew Pad joints, using thread and stitching recommended by the synthetic turf manufacturer.
  4. Lay out work so that seams of the underpad are offset from the seams of turf, but not less than 12".
- G. Turf Installation
1. The synthetic turf shall be bonded to the pad with no wrinkles, ripples or bubbles. Slits in the fabric to relieve such defects are not permitted. Joints in the turf shall be offset from joints of the pad by not less than 12".
  2. Side seams in the fabric shall be at 15'-0" intervals, at 5-yard lines for the football field. There shall be no cross or head seams.
  3. Sew seams with high strength polyester fiber cord and lay with a bed of adhesive. Seams shall be flat, tight and permanent, with no separation or fraying.
  4. Covers for the baseball infield cut-outs shall be flush and tight. Install covers and check for proper fittings.
  5. Insert edges of turf in trench drain receptor at perimeter of field for "float drain" systems; terminated edges at concrete curb and wood nailer at "vertical drain" systems.
  6. Provide covering caps for football and soccer goal posts and markers within the playing fields.
  7. At completion, remove all excess materials and all debris resulting from operations of Work in this Section. Leave entire Work in neat, clean condition.
- H. Painting
1. Lines and markings for game fields shall be painted in accordance with the approved Shop Drawings.
  2. Any logo shall be painted at midfield in accordance with the approved Shop Drawings.
- I. Maintenance
1. Manual shall describe the materials, devices and procedures to be followed for use and maintenance of the synthetic turf system, including the cleaning, paint application and removal, and conversion techniques. Include any precautions required by the warranty.
  2. Training: Give demonstrations and training sessions, devoting a sufficient amount of time to thoroughly instruct the Owner's personnel in operation and maintenance (for cleaning, conversion of baseball-to-football, and line striping) of the synthetic turf system and equipment.
- J. Acceptance
1. Before the acceptance of the work, should any imperfect areas or spots develop in the surface, such areas shall be removed and replaced with new materials.
  2. All such repair work shall be done at no additional cost to the Owner.
- K. At the completion of the Work, remove all material scraps, debris, and equipment from the site and leave the synthetic turf area ready for use.

END OF SECTION 32 18 23 29a

NOT FOR BID

Task	Specification	Specification Description
32 18 23 29	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 29	11 68 23 13	Playing Fields
32 18 23 33	32 18 23 29	Colored Athletic Wearing Surface
32 18 23 33	32 18 23 29a	Synthetic Turf
32 18 23 33	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 33	32 18 16 13b	Synthetic Running Track Surface
32 18 23 39	32 18 23 29	Colored Athletic Wearing Surface
32 18 23 39	32 18 23 29a	Synthetic Turf
32 18 23 39	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 39	32 18 16 13b	Synthetic Running Track Surface
32 18 23 53	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 53	11 68 23 13	Playing Fields
32 18 23 56	32 18 23 29	Colored Athletic Wearing Surface
32 18 23 56	32 18 23 29a	Synthetic Turf
32 18 23 56	32 18 16 13a	Track, Court, And Playground Markings
32 18 23 56	11 68 23 13	Playing Fields
32 18 23 61	32 18 23 29	Colored Athletic Wearing Surface
32 18 23 61	32 18 23 29a	Synthetic Turf
32 18 23 61	32 18 16 13a	Track, Court, And Playground Markings

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## SECTION 32 31 11 00 - CHAIN-LINK FENCES AND GATES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for chain-link fences and gates. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Chain-link fences.
  - b. Gates: Manually and Motor operated, horizontal slide and swing.

#### C. Performance Requirements

1. Delegated Design: Design chain-link fences and gates, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Structural Performance: Chain-link fence and gate framework shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7:
  - a. Minimum Post Size and Maximum Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified and on the following:
    - 1) Wind Loads: **<Insert loads required for Project location>**.
    - 2) Exposure Category: **B OR C OR D, as directed**.
    - 3) Fence Height: **10 feet (3 m)**.
    - 4) Material Group: **IA, ASTM F 1043, Schedule 40 steel pipe OR IC, electric-resistance-welded round steel pipe, as directed**.
3. Lightning Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

#### D. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates.
  - a. Fence and gate posts, rails, and fittings.
  - b. Chain-link fabric, reinforcements, and attachments.
  - c. Accessories: Privacy slats **OR** Barbed wire **OR** Barbed tape, **as directed**.
  - d. Gates and hardware.
  - e. Gate operators, including operating instructions.
  - f. Motors: Show nameplate data, ratings, characteristics, and mounting arrangements.
2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.
  - a. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
  - b. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: Prepared on Samples of size indicated below:
  - a. Polymer-Coated Components: In **6-inch (150-mm)** lengths for components and on full-sized units for accessories.
4. Delegated-Design Submittal: For chain-link fences and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.



5. Qualification Data: For qualified professional engineer **OR** testing agency **OR** factory-authorized service representative, **as directed**.
6. Product Certificates: For each type of chain-link fence, operator, and gate, from manufacturer.
7. Product Test Reports: For framing strength according to ASTM F 1043.
8. Field quality-control reports.
9. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
  - a. Polymer finishes.
  - b. Gate hardware.
  - c. Gate operator.
10. Warranty: Sample of special warranty.

#### E. Quality Assurance

1. Testing Agency Qualifications: For testing fence grounding. Member company of NETA or an NRTL.
  - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for gates with automatic gate operators serving as a required means of access.
4. Preinstallation Conference: Conduct conference at Project site.

#### F. Project Conditions

1. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

#### G. Warranty

1. Special Warranty: Manufacturer's standard form in which manufacturer **OR** Installer, **as directed**, agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
  - a. Failures include, but are not limited to, the following:
    - 1) Faulty operation of gate operators and controls.
    - 2) Deterioration of metals, metal finishes, and other materials beyond normal weathering.
  - b. Warranty Period: Five **OR** 15, **as directed**, years from date of Final Completion.

### 1.2 PRODUCTS

#### A. Chain-Link Fence Fabric

1. General: Provide fabric in one-piece heights measured between top and bottom of outer edge of selva knuckle or twist. Comply with CLFMI Product Manual and with requirements indicated below:
  - a. Fabric Height: As indicated on Drawings **OR** As directed.
  - b. Steel Wire Fabric: Wire with a diameter of **0.192 inch (4.88 mm) OR 0.148 inch (3.76 mm) OR 0.120 inch (3.05 mm) OR 0.113 inch (2.87 mm), as directed**.
    - 1) Mesh Size: **2-1/8 inches (54 mm) OR 2 inches (50 mm) OR 1-3/4 inches (44 mm) OR 1 inch (25 mm), as directed**.
    - 2) Aluminum-Coated Fabric: ASTM A 491, Type I, **0.40 oz./sq. ft. (122 g/sq. m) OR 0.35 oz./sq. ft. (107 g/sq. m) OR 0.30 oz./sq. ft. (92 g/sq. m), as directed**.
    - 3) Zinc-Coated Fabric: ASTM A 392, Type II, Class 1, **1.2 oz./sq. ft. (366 g/sq. m) OR Class 2, 2.0 oz./sq. ft. (610 g/sq. m), as directed**, with zinc coating applied before **OR** after, **as directed**, weaving.

- 4) Zn-5-Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F 1345, Type III, Class 1, **0.60 oz./sq. ft. (183 g/sq. m)** OR Class 2, **1.0 oz./sq. ft. (305 g/sq. m)**, **as directed**.
  - 5) Polymer-Coated Fabric: ASTM F 668, Class 1 OR Class 2a OR Class 2b, **as directed**, over aluminum OR zinc OR Zn-5-Al-MM-alloy, **as directed**, -coated steel wire.
    - a) Color: Dark green OR Olive green OR Brown OR Black OR As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.
  - 6) Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.
  - c. Aluminum Wire Fabric: ASTM F 1183, with mill OR caustic-cleaned or etched, **as directed**, finish, and wire diameter of **0.148 inch (3.76 mm)** OR **0.192 inch (4.88 mm)**, **as directed**.
    - 1) Mesh Size: **2 inches (50 mm)** OR **1 inch (25 mm)**, **as directed**.
  - d. Selvage: Knuckled at both selvages OR Twisted top and knuckled bottom, **as directed**.
- B. Fence Framing
1. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts. Provide members with minimum dimensions and wall thickness according to ASTM F 1043 or ASTM F 1083, **as directed**, based on the following:
    - a. Fence Height: **72 inches (1830 mm)** OR **96 inches (2440 mm)** OR As indicated on Drawings, **as directed**.
    - b. Light Industrial Strength: Material Group IC-L, round steel pipe, electric-resistance-welded pipe OR Group II-L, roll-formed steel C-section shapes OR Group III-L, hot-rolled H-beam shapes OR Group IV, Alternative Design, **as directed**.
      - 1) Line Post: **1.9 inches (48 mm)** in diameter OR **2.375 inches (60 mm)** in diameter OR **2.875 inches (73 mm)** in diameter OR **2.25 by 1.7 inches (57 by 43 mm)**, **as directed**.
      - 2) End, Corner and Pull Post: **2.375 inches (60 mm)** OR **2.875 inches (73 mm)** OR **4.0 inches (102 mm)** OR **2.25 by 1.7 inches (57 by 43 mm)**, **as directed**.
    - c. Heavy Industrial Strength: Material Group IA, round steel pipe, Schedule 40 OR Group IC, round steel pipe, electric-resistance-welded pipe OR Group II, roll-formed steel C-section shapes OR Group III, hot-rolled H-beam shapes OR Group IV, Alternative Design, **as directed**.
      - 1) Line Post: **1.9 inches (48 mm)** in diameter OR **2.375 inches (60 mm)** in diameter OR **2.875 inches (73 mm)** in diameter OR **4.0 inches (102 mm)** in diameter OR **6.625 inches (168 mm)** in diameter OR **1.875 by 1.63 inches (48 by 41 mm)** OR **2.25 by 1.70 inches (67 by 43 mm)** OR **3.25 by 2.50 inches (83 by 64 mm)**, **as directed**.
      - 2) End, Corner and Pull Post: **2.375 inches (60 mm)** in diameter OR **2.875 inches (73 mm)** in diameter OR **4.0 inches (102 mm)** in diameter OR **6.625 inches (168 mm)** in diameter OR **2.25 by 1.70 inches (67 by 43 mm)** OR **3.25 by 2.50 inches (83 by 64 mm)** OR **3.5 by 1.5 inches (89 by 38 mm)**, **as directed**.
    - d. Horizontal Framework Members: Intermediate, top and bottom rails, **as directed**, complying with ASTM F 1043.
      - 1) Top Rail: **1.66 inches (42 mm)** in diameter OR **1.25 by 1.63 inches (32 by 41 mm)**, **as directed**.
    - e. Brace Rails: Comply with ASTM F 1043.
    - f. Metallic Coating for Steel Framing:
      - 1) Type A, consisting of not less than minimum **2.0-oz./sq. ft. (0.61-kg/sq. m)** average zinc coating per ASTM A 123/A 123M or **4.0-oz./sq. ft. (1.22-kg/sq. m)** zinc coating per ASTM A 653/A 653M.
      - 2) Type B, zinc with organic overcoat, consisting of a minimum of **0.9 oz./sq. ft. (0.27 kg/sq. m)** of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
      - 3) External, Type B, zinc with organic overcoat, consisting of a minimum of **0.9 oz./sq. ft. (0.27 kg/sq. m)** of zinc after welding, a chromate conversion coating, and a clear,



verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than **0.3-mil- (0.0076-mm-)** thick, zinc-pigmented coating.

- 4) Type C, Zn-5-Al-MM alloy, consisting of not less than **1.8-oz./sq. ft. (0.55-kg/sq. m)** coating.
- 5) Coatings: Any coating above.
- g. Polymer coating over metallic coating.
  - 1) Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.

#### C. Tension Wire

1. Metallic-Coated Steel Wire: **0.177-inch- (4.5-mm-)** diameter, marcelled tension wire complying with ASTM A 817 and ASTM A 824, with the following metallic coating:
  - a. Type I, aluminum coated (aluminized).
  - b. Type II, zinc coated (galvanized) by hot-dip **OR** electrolytic, **as directed**, process, with the following minimum coating weight:
    - 1) Class 3: Not less than **0.8 oz./sq. ft. (244 g/sq. m)** of uncoated wire surface.
    - 2) Class 4: Not less than **1.2 oz./sq. ft. (366 g/sq. m)** of uncoated wire surface.
    - 3) Class 5: Not less than **2 oz./sq. ft. (610 g/sq. m)** of uncoated wire surface.
    - 4) Matching chain-link fabric coating weight.
  - c. Type III, Zn-5-Al-MM alloy with the following minimum coating weight:
    - 1) Class 60: Not less than **0.6 oz./sq. ft. (183 g/sq. m)** of uncoated wire surface.
    - 2) Class 100: Not less than **1 oz./sq. ft. (305 g/sq. m)** of uncoated wire surface.
    - 3) Matching chain-link fabric coating weight.
2. Polymer-Coated Steel Wire: **0.177-inch- (4.5-mm-)** **OR** **0.148-inch- (3.8-mm-)**, **as directed**, diameter, tension wire complying with ASTM F 1664, Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**, -coated steel wire.
  - a. Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.
3. Aluminum Wire: **0.192-inch- (4.88-mm-)** diameter tension wire, mill finished, complying with **ASTM B 211 (ASTM B211M)**, Alloy 6061-T94 with **50,000-psi (344-MPa)** minimum tensile strength.

#### D. Swing Gates

1. General: Comply with ASTM F 900 for gate posts and single **OR** double, **as directed**, swing gate types. Provide automated vehicular gates that comply with ASTM F 2200, **as directed**.
  - a. Gate Leaf Width: **36 inches (914 mm)** **OR** As indicated, **as directed**.
  - b. Gate Fabric Height: **72 inches (1830 mm)** or less **OR** More than **72 inches (1830 mm)** **OR** As indicated, **as directed**.
2. Pipe and Tubing:
  - a. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; protective coating and finish to match fence framing **OR** manufacturer's standard protective coating and finish, **as directed**.
  - b. Aluminum: Comply with ASTM B 429/B 429M; mill **OR** manufacturer's standard, **as directed**, finish.
  - c. Gate Posts: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
  - d. Gate Frames and Bracing: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
3. Frame Corner Construction: Welded **OR** Assembled with corner fittings, **as directed**.
4. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame **12 inches (300 mm)** **OR** as indicated, **as directed**, to attach barbed wire **OR** tape, **as directed**, assemblies.
5. Hardware:

- a. Hinges: 180-degree inward **OR** 180-degree outward **OR** 360-degree inward and outward, **as directed**, swing.
  - b. Latches permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate, **as directed**.
  - c. Padlock and Chain: Owner furnished.
  - d. Lock: Manufacturer's standard internal device furnished in lieu of gate latch, **as directed**.
  - e. Closer: Manufacturer's standard, **as directed**.
- E. Horizontal-Slide Gates
1. General: Comply with ASTM F 1184 for gate posts and single **OR** double, **as directed**, sliding gate types. Provide automated vehicular gates that comply with ASTM F 2200, **as directed**.
    - a. Classification: Type I Overhead Slide (opening widths to 40 feet (12.2 m) with an overhead clearance of up to 22 feet (6.7 m)).
      - 1) Gate Leaf Width: As indicated **OR** As directed.
      - 2) Gate Fabric Height: **72 inches (1830 mm)** or less **OR** More than **72 inches (1830 mm)** **OR** As indicated, **as directed**.
    - b. Classification: Type II Cantilever Slide (opening widths to 30 feet (9.1 m) and heights to 8 feet (2.44 m))
      - 1) Class 1 with external **OR** Class 2 with internal, **as directed**, roller assemblies.
      - 2) Gate Frame Width and Height: **48 inches (1200 mm)** wide or less by **72 inches (1830 mm)** high or less **OR** More than **48 inches (1200 mm)** wide by any height **OR** As indicated, **as directed**.
  2. Pipe and Tubing:
    - a. Zinc-Coated Steel: Protective coating and finish to match fence framing **OR** Manufacturer's standard protective coating and finish, **as directed**.
    - b. Aluminum: Comply with ASTM B 429/B 429M; mill **OR** manufacturer's standard, **as directed**, finish.
    - c. Gate Posts: Comply with ASTM F 1184. Provide round tubular steel **OR** rectangular tubular steel **OR** round tubular aluminum **OR** rectangular tubular aluminum, **as directed**, posts.
    - d. Gate Frames and Bracing: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
  3. Frame Corner Construction: Welded **OR** Assembled with corner fittings, **as directed**.
  4. Extended Gate Posts and Frame Members: Extend gate posts and frame end members above top of chain-link fabric at both ends of gate frame **12 inches (300 mm)** **OR** as indicated, **as directed**, as required to attach barbed wire **OR** tape, **as directed**, assemblies.
  5. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.
  6. Hardware:
    - a. Latches permitting operation from both sides of gate with provision for padlocking accessible from both sides of gate, **as directed**.
    - b. Padlock and Chain: Owner furnished.
    - c. Lock: Manufacturer's standard internal device furnished in lieu of gate latch, **as directed**.
    - d. Hangers, roller assemblies, and stops fabricated from galvanized steel **OR** galvanized malleable iron **OR** mill-finished Grade 319 aluminum-alloy casting with stainless-steel fasteners, **as directed**.
- F. Fittings
1. General: Comply with ASTM F 626.
  2. Post Caps: Provide for each post.
    - a. Provide line post caps with loop to receive tension wire or top rail.
  3. Rail and Brace Ends: For each gate, corner, pull, and end post.
  4. Rail Fittings: Provide the following:
    - a. Top Rail Sleeves: Pressed-steel or round-steel tubing **OR** Aluminum Alloy 6063, **as directed**, not less than **6 inches (152 mm)** long.

- b. Rail Clamps: Line and corner boulevard clamps for connecting intermediate, and bottom, **as directed**, rails in the fence line-to-line posts.
    5. Tension and Brace Bands: Pressed steel **OR** Aluminum Alloy 6063, **as directed**.
    6. Tension Bars: Steel **OR** Aluminum **OR** Fiberglass, **as directed**, length not less than **2 inches (50 mm)** shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
    7. Truss Rod Assemblies: Steel, hot-dip galvanized after threading **OR** Mill-finished aluminum, **as directed**, rod and turnbuckle or other means of adjustment.
    8. Barbed Wire Arms: Pressed steel or cast iron **OR** Aluminum, **as directed**, with clips, slots, or other means for attaching strands of barbed wire, and means for attaching to posts **OR** integral with post cap, **as directed**; for each post unless otherwise indicated, and as follows:
      - a. Provide line posts with arms that accommodate top rail or tension wire.
      - b. Provide corner arms at fence corner posts, unless extended posts are indicated.
      - c. Type I, single slanted arm.
      - d. Type II, single vertical arm.
      - e. Type III, V-shaped arm.
      - f. Type IV, A-shaped arm.
    9. Tie Wires, Clips, and Fasteners: According to ASTM F 626.
      - a. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
        - 1) Hot-Dip Galvanized Steel: **0.106-inch- (2.69-mm-) OR 0.148-inch- (3.76-mm-)**, **as directed**, diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric, **as directed**.
        - 2) Aluminum: **ASTM B 211 (ASTM B 211M)**; Alloy 1350-H19; **0.148-inch- (3.76-mm-) OR 0.192-inch- (4.88-mm-)**, **as directed**, diameter, mill-finished wire.
    10. Finish:
      - a. Metallic Coating for Pressed Steel or Cast Iron: Not less than **1.2 oz. /sq. ft. (366 g /sq. m)** zinc.
        - 1) Polymer coating over metallic coating.
      - b. Aluminum: Mill finish.
- G. Privacy Slats
1. Material: PVC, UV-light stabilized, flame resistant, four ply, **as directed**, not less than **0.006 inch (0.15 mm) OR 0.023 inch (0.58 mm)**, **as directed**, thick; attached to not less than **0.0475-inch- (1.21-mm-)** diameter, twisted galvanized wire; hedge-type lattice, **as directed**; sized to fit mesh specified for direction indicated.  
**OR**  
 Material: Polyethylene tubular slats, not less than **0.023 inch (0.58 mm)** thick, manufactured for chain-link fences from virgin polyethylene containing UV inhibitor, sized to fit mesh specified for direction indicated; with vandal-resistant fasteners and lock strips **OR** fins for increased privacy factor, **as directed**.  
**OR**  
 Material: Fiber-glass-reinforced plastic, UV-light stabilized, not less than **0.06 inch (1.5 mm)** thick, sized to fit mesh specified for direction indicated; with vandal-resistant fasteners and lock strips, **as directed**.  
**OR**  
 Material: Aluminum, not less than **0.01 inch (0.25 mm)** thick, sized to fit mesh specified for direction indicated.  
**OR**  
 Material: Redwood, **5/16 inch (7.9 mm)** thick, sized to fit mesh specified for direction indicated.
  2. Color: As indicated by manufacturer's designations **OR** As selected from manufacturer's full range **OR** As indicated on Drawings, **as directed**.
- H. Barbed Wire

1. Steel Barbed Wire: Comply with ASTM A 121, for two-strand barbed wire, **0.099-inch- (2.51-mm-)** diameter line wire with **0.080-inch- (2.03-mm-)** diameter, four-point round barbs spaced not more than **5 inches (127 mm)** o.c.
    - a. Aluminum Coating: Type A.
    - b. Zinc Coating: Type Z, Class 3.
  2. Polymer-Coated, Galvanized-Steel Barbed Wire: Comply with ASTM F 1665 two-strand barbed wire, **0.080-inch- (2.03-mm-)** diameter line wire with **0.080-inch- (2.03-mm-)** diameter, four-point round aluminum alloy **OR** galvanized-steel, **as directed**, barbs spaced not more than **5 inches (127 mm)** o.c.:
    - a. Polymer Coating: Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**, -coated steel wire.
      - 1) Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.
- I. Barbed Tape
1. Wire-Reinforced Tape: ASTM F 1910; with four-point, needle-sharp barbs permanently cold clenched around a core wire.
    - a. Core Wire: High-tensile-strength, zinc-coated steel **OR** stainless steel, **as directed**.
  2. Clips: Stainless steel, **0.065 inch (1.7 mm)** thick by **0.375 inch (9.5 mm)** wide, capable of withstanding a minimum **150-lbf (667-N)** pull load to limit extension of coil, resulting in a concertina pattern when deployed.
  3. Tie Wires: Stainless steel, **0.065 inch (1.7 mm)** in diameter.
  4. Fabrication: Continuous coils of barbed tape as defined in ASTM F 1379 for the following characteristics:
    - a. Configuration: Single **OR** Double, **as directed**, coil.
    - b. Style: Helical **OR** Concertina, **as directed**, pattern.
    - c. Coil Diameter(s): **18 inches (457 mm) OR 24 inches (610 mm) OR 24-inch (610-mm)** inner coil and **30-inch (762-mm)** outer coil **OR** As indicated on Drawings, **as directed**.
    - d. Coil Loop Spacing(s): **12 inches (300 mm) OR** Manufacturer's standard **OR** As indicated on Drawings, **as directed**.
    - e. Barb Length Classification: Long, **1.2-inch (30.5-mm) OR** Medium, **0.4-inch (10.2-mm) OR** Short, **0.1875-inch (4.76-mm)**, **as directed**, barb.
    - f. Barb Spacing: **4 inches (102 mm)** o.c.
    - g. Barb Set: Straight **OR** Offset **OR** Manufacturer's standard, **as directed**.
- J. Gate Operators
1. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
    - a. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
    - b. Provide operator with UL approval **OR** -approved components, **as directed**.
    - c. Provide electronic components with built-in troubleshooting diagnostic feature.
    - d. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.
  2. Comply with NFPA 70.
  3. UL Standard: Fabricate and label gate operators to comply with UL 325.
  4. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
    - a. Voltage: 12-V dc **OR** 120 V **OR** 208-220 V **OR** NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected, **as directed**.
    - b. Horsepower: 1/4 **OR** 1/3 **OR** 3/4, **as directed**.
    - c. Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.

- d. Duty: Continuous duty at ambient temperature of **105 deg F (40 deg C)** and at altitude of **3300 feet (1005 m)** above sea level.
- e. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
- f. Phase: One **OR** Polyphase, **as directed**.
- 5. Gate Operators: Gate **OR** Equipment base/pad **OR** Pedestal post **OR** In ground, **as directed**, mounted and as follows:
  - a. Hydraulic Swing **OR** Slide, **as directed**, Gate Operators:
    - 1) Duty: Light **OR** Medium **OR** Heavy, **as directed**, duty, residential **OR** commercial/industrial, **as directed**.
    - 2) Gate Speed: Minimum **45 feet (13.7 m) OR 60 feet (18.2 m)**, **as directed**, per minute.
    - 3) Maximum Gate Weight: **300 lb (137 kg)**.
    - 4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** Continuous duty, **as directed**.
    - 5) Locking: Hydraulic in both directions.
    - 6) Heater: Manufacturer's standard track and roller heater with thermostatic control.
    - 7) Operating Type: Crank arm **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
  - b. Mechanical Swing **OR** Slide, **as directed**, Gate Operators:
    - 1) Duty: Light **OR** Medium **OR** Heavy, **as directed**, duty, residential **OR** commercial/industrial, **as directed**.
    - 2) Gate Speed: Minimum **45 feet (13.7 m)** per minute **OR 60 feet (18.2 m)** per minute **OR** variable speed, **as directed**.
    - 3) Maximum Gate Weight: **600 lb (272 kg) OR 800 lb (363 kg)**, **as directed**.
    - 4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** 60 cycles per hour **OR** Continuous duty, **as directed**.
    - 5) Operating Type: Crank arm **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
    - 6) Drive Type: Enclosed worm gear **OR** worm gear and chain-and-sprocket, **as directed**, reducers, roller-chain drive.  
**OR**  
Drive Type: V-belt and worm gear **OR** chain-and-sprocket, **as directed**, reducers, roller-chain drive.
- 6. Remote Controls: Electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 **OR** NEMA ICS 6, Type 4, **as directed**, enclosure for surface **OR** recessed or flush **OR** equipment base/pad **OR** pedestal, **as directed**, mounting and with space for additional optional equipment. Provide the following remote-control device(s):
  - a. Control Station: Keyed, two **OR** three, **as directed**, -position switch, located remotely from gate. Provide two keys per station.  
**OR**  
Control Station: Momentary-contact, single **OR** three, **as directed**, -button-operated; located remotely from gate. Key switch to lock out open and close buttons, **as directed**.
    - 1) Function: Open, stop, **as directed**, and close.
  - b. Card Reader: Functions only when authorized card is presented. Programmable, magnetic multiple **OR** single, **as directed**, -code system, permitting four different access time periods, **as directed**; face-lighted unit fully visible at night, **as directed**.
    - 1) Reader Type: Touch plate **OR** Swipe **OR** Insertion **OR** Proximity, **as directed**.
    - 2) Features: Timed anti-passback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
  - c. Digital Keypad Entry Unit: Multiple-code capability **OR** Multiple-programmable, code capability, **as directed**, of not less than five **OR** 500 **OR** 2500, **as directed**, possible individual codes, consisting of one- to seven **OR** four **OR** five, **as directed**, -digit codes, and permitting four different access time periods, **as directed**.
    - 1) Features: Timed anti-passback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.



- 2) Face-lighted unit with metal-keyed **OR** keyless-membrane, **as directed**, keypad fully visible at night.
- d. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide one **OR** two, **as directed**, programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than 1000 **OR** 10,000, **as directed**, codes per channel configured for the following functions:
  - 1) Transmitters: Single **OR** Three, **as directed**, button operated, with open **OR** open and close, **as directed**, function.
  - 2) Channel Settings: Two **OR** Three **OR** Four, **as directed**, independent channel settings controlling separate receivers for operating more than one gate from each transmitter.
- e. Telephone Entry System: Hands-free voice-communication system for connection to building telephone system with digital-entry code activation of gate operator and auxiliary keypad entry, **as directed**.
  - 1) Residential System: Designed to be wired to same line with telephone.  
**OR**  
Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access 20 **OR** 100, **as directed**, telephones and with electronic directory, **as directed**.
- f. Vehicle Loop Detector: System including automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and loop detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, as recommended in writing by detection system manufacturer for function indicated.
  - 1) Loop: Wire, in size indicated for field assembly, for pave-over **OR** saw-cut with epoxy-grouted, **as directed**, installation.  
**OR**  
Loop: Factory preformed in size indicated; style for pave-over **OR** saw-cut with epoxy-grouted, **as directed**, installation.
- g. Vehicle Presence Detector: System including automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and presence detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide retroreflective **OR** emitter/receiver, **as directed**, detector with adjustable detection zone pattern and sensitivity, designed to detect the presence or transit of a vehicle in gate pathway when infrared beam in zone pattern is interrupted, and to emit a signal activating the gate operator.
7. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
  - a. Action: Reverse gate in both opening and closing cycles and hold until clear of obstruction **OR** Stop gate in opening cycle and reverse gate in closing cycle and hold until clear of obstruction, **as directed**.
  - b. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
  - c. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as follows. Connect to control circuit using take-up cable reel **OR** self-coiling cable **OR** gate edge transmitter and operator receiver system, **as directed**.
    - 1) Along entire gate leaf leading edge (for swing gates and slide gates).
    - 2) Along entire gate leaf trailing edge (for slide gates).
    - 3) Across entire gate leaf bottom edge (for vehicular swing and slide gates complying with UL 325 or to suit Project; consider retaining for pedestrian gates).

- 4) Along entire length of gate posts (for slide gates; revise for sensor edge at pinch point post of swing gates).
- 5) Along entire length of gate guide posts (for Type II Cantilever Slide, Class 1 gates).
- 6) Where indicated on Drawings.
- d. Photoelectric/Infrared Sensor System: Designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.
8. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully retracted and fully extended positions.
  - a. Type: Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge **OR** Mechanical device, key, or crank-activated release, **as directed**.
9. Operating Features:
  - a. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features with capability for monitoring and auditing gate activity, **as directed**. Provide unit that is isolated from voltage spikes and surges.
  - b. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
  - c. Master/Slave Capability: Control stations designed and wired for gate pair operation.
  - d. Automatic Closing Timer: With adjustable time delay before closing and timer cut-off switch, **as directed**.
  - e. Open Override Circuit: Designed to override closing commands.
  - f. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
  - g. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
  - h. Clock Timer: 24-hour **OR** Seven-day, **as directed**, programmable for regular events.
10. Accessories:
  - a. Warning Module: Audio **OR** Visual, **as directed**, constant **OR** strobe, **as directed**, light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines.
  - b. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
    - 1) Fail Safe: Gate opens and remains open until power is restored.
    - 2) Fail Secure: Gate cycles on battery power, then fail safe when battery is discharged.
  - c. External electric-powered solenoid **OR** magnetic, **as directed**, lock with delay timer allowing time for lock to release before gate operates.
  - d. Fire **OR** Postal, **as directed**, box.
  - e. Fire strobe **OR** siren, **as directed**, alarm.
  - f. Intercom System: **<Insert requirements>**.
  - g. Instructional, Safety, and Warning Labels and Signs: According to UL 325 **OR** Manufacturer's standard for components and features specified **OR** As indicated on Drawings, **as directed**.
  - h. Equipment Bases/Pads: Cast-in-place or precast concrete, depth not less than **12 inches (300 mm)**, dimensioned and reinforced according to gate-operator component manufacturer's written instructions and as indicated on Drawings.

K. Grout And Anchoring Cement

1. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.
2. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to

erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer, for exterior applications.

- L. Fence Grounding
  - 1. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
    - a. Material above Finished Grade: Copper **OR** Aluminum, **as directed**.
    - b. Material on or below Finished Grade: Copper.
    - c. Bonding Jumpers: Braided copper tape, **1 inch (25 mm)** wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
  - 2. Connectors and Grounding Rods: Comply with UL 467.
    - a. Connectors for Below-Grade Use: Exothermic welded type.
    - b. Grounding Rods: Copper-clad steel, **5/8 by 96 inches (16 by 2440 mm)**.

### 1.3 EXECUTION

- A. Examination
  - 1. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, **as directed**, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
    - a. Do not begin installation before final grading is completed unless otherwise permitted by the Owner.
  - 2. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Preparation
  - 1. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of **500 feet (152.5 m)** or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.
- C. Installation, General
  - 1. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements indicated.
    - a. Install fencing on established boundary lines inside property line.
- D. Chain-Link Fence Installation
  - 1. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
  - 2. Post Setting: Set posts in concrete **OR** with mechanical anchors **OR** by mechanically driving into soil, **as directed**, at indicated spacing into firm, undisturbed soil.
    - a. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
    - b. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
      - 1) Exposed Concrete: Extend **2 inches (50 mm)** above grade; shape and smooth to shed water.
      - 2) Concealed Concrete: Top **2 inches (50 mm)** below grade as indicated on Drawings to allow covering with surface material.
      - 3) Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout **OR** anchoring cement, **as directed**, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
      - 4) Posts Set into Voids in Concrete: Form or core drill holes not less than **5 inches (125 mm)** deep and **3/4 inch (20 mm)** larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with



- nonshrink, nonmetallic grout **OR** anchoring cement, **as directed**, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
- c. Mechanically Driven Posts: Drive into soil to depth of **30 inches (762 mm) OR 36 inches (914 mm), as directed**. Protect post top to prevent distortion.
  3. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more **OR** 30 degrees or more **OR** as indicated on Drawings, **as directed**.
  4. Line Posts: Space line posts uniformly at **96 inches (2440 mm) OR 10 feet (3 m), as directed**, o.c.
  5. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.
    - a. Locate horizontal braces at midheight of fabric **72 inches (1830 mm)** or higher, on fences with top rail and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
  6. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with **0.120-inch- (3.05-mm-) diameter hog rings** of same material and finish as fabric wire, spaced a maximum of **24 inches (610 mm)** o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
    - a. Extended along top **OR** bottom **OR** top and bottom, **as directed**, of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within **6 inches (152 mm)** of bottom of fabric and tie to each post with not less than same diameter and type of wire.
    - b. Extended along top of barbed wire arms **OR** extended posts, **as directed**, and top of fence fabric for supporting barbed tape.
    - c. As indicated.
  7. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
  8. Intermediate and Bottom Rails: Install and secure to posts with fittings.
  9. Chain-Link Fabric: Apply fabric to outside **OR** inside, **as directed**, of enclosing framework. Leave **1 inch (25.4 mm) OR 2 inches (50 mm), as directed**, between finish grade or surface and bottom selvage unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
  10. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than **15 inches (380 mm)** o.c.
  11. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at one end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
    - a. Maximum Spacing: Tie fabric to line posts at **12 inches (300 mm)** o.c. and to braces at **24 inches (610 mm)** o.c.
  12. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts, **as directed**.
  13. Privacy Slats: Install slats in direction indicated, securely locked in place.
    - a. Vertically **OR** Horizontally, **as directed**, for privacy factor of 70 to 75.  
**OR**  
Diagonally, for privacy factor of 80 to 85.  
**OR**  
Direction and privacy factor, **as directed**, as indicated.

14. Barbed Wire: Install barbed wire uniformly spaced, angled toward security side of fence **OR** as indicated on Drawings, **as directed**. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.
  15. Barbed Tape: Comply with ASTM F 1911. Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.
- E. Gate Installation
1. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.
- F. Gate Operator Installation
1. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.
  2. Excavation for Support Posts **OR** Pedestals **OR** Equipment Bases/Pads, **as directed**: Hand-excavate holes for bases/pads, in firm, undisturbed soil to dimensions and depths and at locations as required by gate-operator component manufacturer's written instructions and as indicated.
  3. Vehicle Loop Detector System: Cut grooves in pavement and bury **OR** Bury, **as directed**, and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.
  4. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.
- G. Grounding And Bonding
1. Fence Grounding: Install at maximum intervals of **1500 feet (450 m)**, **as directed**, except as follows:
    - a. Fences within **100 Feet (30 m)** of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of **750 feet (225 m)**, **as directed**.
      - 1) Gates and Other Fence Openings: Ground fence on each side of opening.
        - a) Bond metal gates to gate posts.
        - b) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least **18 inches (460 mm)** below finished grade.
  2. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of **150 feet (45 m)** on each side of crossing.
  3. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
  4. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is **6 inches (150 mm)** below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location, including the following:
    - a. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
    - b. Make grounding connections to each barbed tape coil with connectors designed for this purpose.
  5. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
  6. Connections: Make connections to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
    - a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
    - b. Make connections with clean, bare metal at points of contact.
    - c. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.



- d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
- e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
7. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

#### H. Field Quality Control

1. Grounding-Resistance Testing: Engage a qualified testing agency to perform tests and inspections.
  - a. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance no fewer than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
  - b. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify the Owner promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
  - c. Report: Prepare test reports certified by a testing agency of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

#### I. Adjusting

1. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
2. Automatic Gate Operator: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, alarms, **as directed**, and limit switches.
  - a. Hydraulic Operator: Purge operating system, adjust pressure and fluid levels, and check for leaks.
  - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - c. Test and adjust controls, alarms, **as directed**, and safeties. Replace damaged and malfunctioning controls and equipment.
3. Lubricate hardware, gate operator, **as directed**, and other moving parts.

#### J. Demonstration

1. Train the Owner's personnel to adjust, operate, and maintain chain-link fences and gates.

END OF SECTION 32 31 11 00

## SECTION 32 31 13 13 - HIGH-SECURITY CHAIN-LINK FENCES AND GATES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for high-security chain-link fences and gates. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. High-security chain-link fences.
  - b. Gates: Motor operated, horizontal slide and swing.

#### C. Performance Requirements

1. Delegated-Design Submittal: For chain-link fences and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
2. Structural Performance: Chain-link fences and gate framework shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7:
  - a. Minimum Post Size: Determine according to ASTM F 1043 for framework up to **12 feet (3.66 m)** high, and post spacing not to exceed **10 feet (3 m)** for Material Group IA, ASTM F 1043, Schedule 40 steel pipe **OR** Group IC, electric-resistance-welded round steel pipe, **as directed**.  
**OR**  
Minimum Post Size and Maximum Spacing: Provide line posts of size and in spacing indicated, but not less than sizes and spacings determined according to ASTM F 1916, including Appendix **OR** CLFMI WLG 2445, **as directed**, based on mesh size and pattern specified and the following:
    - 1) Wind Loads: Determine design wind loads applicable to Project from basic wind speed and exposure category according to CLFMI WLG 2445.
    - 2) Exposure Category: **B OR C OR D, as directed**.
    - 3) Fence Height: **10 feet (3 m)**.
    - 4) Material Group: **IA, ASTM F 1043, Schedule 40 steel pipe OR IC, electric-resistance-welded round steel pipe, as directed**.
  - b. Fabric Tension: Provide fences in which fabric deflections do not exceed those indicated in Table X1.1 of ASTM F 1916 when tested by applying a **30-lbf (133-N)** force at midpoint between rails and horizontally between posts for every eighth lower panel along the fence line.
  - c. Fence Post Rigidity: Provide fences in which post deflections do not exceed **3/4 inch (19 mm)** when tested according to ASTM F 1916 by applying a **50-lbf (222-N)** force at midheight of every eighth post along the fence line.
3. Lightning Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

#### D. Submittals

1. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates, **as directed**.
  - a. Fence and gate posts, rails, and fittings.
  - b. Chain-link fabric, reinforcements, and attachments.
  - c. Accessories: Barbed wire **OR** Barbed tape, **as directed**.

- d. Gates and hardware.
  - e. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
  - f. Wiring Diagrams: For power, signal, and control wiring.
  2. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.
    - a. Gate Operator: Show locations and details for installing operator components, switches, and controls. Indicate motor size, electrical characteristics, drive arrangement, mounting, and grounding provisions.
    - b. Wiring Diagrams: For power, signal, and control wiring.
  3. Samples: Prepared on Samples of size indicated below:
    - a. Polymer-Coated Components: In **6-inch (150-mm)** lengths for components and on full-sized units for accessories.
  4. Delegated-Design Submittal: For chain-link fences and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  5. Qualification Data: For qualified professional engineer **OR** testing agency **OR** factory-authorized service representative, **as directed**.
  6. Product Certificates: For each type of chain-link fence, operator, **as directed**, and gate, from manufacturer.
  7. Product Test Reports: For framing strength according to ASTM F 1043.
  8. Field quality-control reports.
  9. Soil sterilization certificate of treatment stating materials and quantities used, and date of application.
  10. Operation and Maintenance Data: For the following to include in emergency, operation, and maintenance manuals:
    - a. Polymer finishes.
    - b. Gate hardware.
    - c. Gate operator.
  11. Warranty: Sample of special warranty.
- E. Quality Assurance
1. Testing Agency Qualifications: For testing fence grounding. Member company of NETA or an NRTL **OR** one who meets the requirements necessary for certification, **as directed**.
    - a. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing **OR** one who meets the requirements necessary for certification, **as directed**.
  2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
  3. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for automatic gate operators serving as a required means of access.
  4. Preinstallation Conference: Conduct conference at Project site.
- F. Project Conditions
1. Field Measurements: Verify layout information for chain-link fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.
- G. Warranty
1. Special Warranty: Manufacturer's standard form in which manufacturer **OR** Installer, **as directed**, agrees to repair or replace components of high-security chain-link fences and gates that fail in materials or workmanship within specified warranty period.
    - a. Failures include, but are not limited to, the following:
      - 1) Deflection of fence fabric beyond design limits.



- 2) Deterioration of metals, metal finishes, and other materials beyond normal weathering.
- 3) Faulty operation of gate operators and controls.
- b. Warranty Period: Five **OR** 15, **as directed**, years from date of Final Completion.

## 1.2 PRODUCTS

### A. Chain-Link Fence Fabric

1. Chain-Link Fence Fabric: Provide fabric in one **OR** two, **as directed**, -piece heights measured between top and bottom of outer edge of selvage. Comply with CLFMI Product Manual and with requirements indicated below:
  - a. Fabric Height: As indicated on Drawings **OR** As directed.
    - 1) Steel Wire Fabric: Wire with a diameter of **0.192 inch (4.88 mm) OR 0.148 inch (3.76 mm) OR 0.120 inch (3.05 mm) OR 0.113 inch (2.87 mm), as directed.**
      - a) Mesh Size: **2 inches (51 mm) OR 1 inch (25.4 mm) OR 3/8 inch (9.5 mm), as directed.**
  - b. Fabric Heights and Overlap: As indicated on Drawings **OR** As directed.
    - 1) Steel Wire Lower Fabric: Wire with a diameter of **0.192 inch (4.88 mm) OR 0.148 inch (3.76 mm) OR 0.120 inch (3.05 mm) OR 0.113 inch (2.87 mm), as directed.**
      - a) Mesh Size: **2 inches (51 mm) OR 1 inch (25.4 mm) OR 3/8 inch (9.5 mm), as directed.**
    - 2) Steel Wire Upper Fabric: Wire with a diameter of 0.120 inch (3.05 mm).
      - a) Mesh Size: **3/8 inch (9.5 mm).**
  - c. Aluminum-Coated Fabric: ASTM A 491, Type I, **0.40 oz./sq. ft. (122 g/sq. m) OR 0.35 oz./sq. ft. (107 g/sq. m) OR 0.30 oz./sq. ft. (92 g/sq. m), as directed.**
  - d. Zinc-Coated Fabric: ASTM A 392, Type II, Class 1, **1.2 oz./sq. ft. (366 g/sq. m) OR Class 2, 2.0 oz./sq. ft. (610 g/sq. m), as directed**, with zinc coating applied before **OR** after, **as directed**, weaving.
  - e. Zn-5-Al-MM Aluminum-Mischmetal-Coated Fabric: ASTM F 1345, Type III, Class 2, **1.0 oz./sq. ft. (305 g/sq. m).**
  - f. Polymer-Coated Fabric: ASTM F 668, Class 2b over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**, -coated steel wire.
    - 1) Color: Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected by the Owner from manufacturer's full range, **as directed**, complying with ASTM F 934.
  - g. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.
  - h. Selvage: Twisted and barbed top and bottom.

### B. Security Fence Framing

1. Posts and Rails: Comply with ASTM F 1043 for framing, including rails, braces, and line; terminal; and corner posts.
  - a. Fence Height: **96 inches (2440 mm) OR 12 feet (3.66 m) OR** As indicated on Drawings, **as directed.**
  - b. Heavy **OR** Light, **as directed**, Industrial Strength: Material Group IA, round steel pipe, Schedule 40 **OR** Group IC, round steel pipe, electric resistance-welded pipe, **as directed.**
    - 1) Line Post: **2.375 inches (60 mm) in diameter OR 2.875 inches (73 mm) in diameter OR 4 inches (100-mm) in diameter OR 6.625 inches (168 mm) in diameter OR 8.625 inches (168 mm) in diameter OR 2.25 by 1.70 inches (67 by 43 mm) OR 3.25 by 2.50 inches (83 by 64 mm), as directed.**
    - 2) End, Corner, and Pull Post: **2.875 inches (73 mm) in diameter OR 4.0 inches (102 mm) in diameter OR 6.625 inches (168 mm) in diameter OR 8.625 inches (168 mm) in diameter, as directed.**
  - c. Rail Members: Intermediate, top, and brace, **as directed**, rails complying with ASTM F 1043 for Heavy Industrial.
  - d. Metallic Coating for Steel Framing:

- 1) Type A, consisting of not less than minimum **2.0-oz./sq. ft. (0.61-kg/sq. m)** average zinc coating per ASTM A 123/A 123M or **4.0-oz./sq. ft. (1.22-kg/sq. m)** zinc coating per ASTM A 653/A 653M.
  - 2) Type B, zinc with organic overcoat, consisting of a minimum of **0.9 oz./sq. ft. (0.27 kg/sq. m)** of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film.
  - 3) External, Type B, zinc with organic overcoat, consisting of a minimum of **0.9 oz./sq. ft. (0.27 kg/sq. m)** of zinc after welding, a chromate conversion coating, and a clear, verifiable polymer film. Internal, Type D, consisting of 81 percent, not less than **0.3-mil- (0.0076-mm-)** thick, zinc-pigmented coating.
  - 4) Type C, Zn-5-Al-MM alloy, consisting of not less than **1.8-oz./sq. ft. (0.55-kg/sq. m)** coating.
  - 5) Coatings: Any coating above.
  - e. Polymer coating over metallic coating.
    - 1) Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.
- C. Tension Wire
1. Metallic-Coated Steel Wire: **0.177-inch- (4.5-mm-)** diameter, marcelled tension wire complying with ASTM A 817 and ASTM A 824, with the following metallic coating:
    - a. Type I, aluminum coated (aluminized).
    - b. Type II, zinc coated (galvanized) by hot-dip **OR** electrolytic, **as directed**, process, with Class 5 minimum coating weight of not less than **2.0 oz./sq. ft. (610 g/sq. m)** of uncoated wire surface.
  2. Polymer-Coated Steel Wire: **0.177-inch- (4.5-mm-)** diameter, tension wire complying with ASTM F 1664, Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**, -coated steel wire.
    - a. Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.
- D. Swing Gates
1. General: Comply with ASTM F 900 for gate posts and single **OR** double, **as directed**, swing gate types. Provide automated vehicular gates that comply with ASTM F 2200, **as directed**.
    - a. Gate Leaf Width: **36 inches (914 mm)** **OR** As indicated, **as directed**.
    - b. Gate Fabric Height: **72 inches (1830 mm)** or less **OR** More than **72 inches (1830 mm)** **OR** As indicated, **as directed**.
  2. Pipe and Tubing:
    - a. Zinc-Coated Steel: Comply with ASTM F 1043 and ASTM F 1083; protective coating and finish to match fence framing **OR** manufacturer's standard protective coating and finish, **as directed**.
    - b. Aluminum: Comply with ASTM B 429/B 429M; mill **OR** manufacturer's standard, **as directed**, finish.
    - c. Gate Post Size and Weight: Not less than required by ASTM F 900 **OR** ASTM F 1916, **as directed**.
    - d. Gate Posts: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
    - e. Gate Frames and Bracing: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
  3. Frame Corner Construction: Welded **OR** Assembled with corner fittings, **as directed**, and **3/8-inch- (9.5-mm-)** diameter, adjustable truss rods for panels **5 feet (1.52 m)** or wider.
  4. Extended Gate Posts and Frame Members: Extend above top of chain-link fabric at both ends of gate frame **12 inches (300 mm)** **OR** as indicated, **as directed**, as required to attach barbed wire **OR** tape, **as directed**, assemblies.
  5. Provide separate isolated gate frame according to ASTM F 1916 and as indicated.

- a. Separation between Hinge and Latch Post and Fence Termination Post: **2 inches (51 mm)** minimum, **2-1/2 inches (63.5 mm)** maximum.
  6. Hardware: Comply with ASTM F 1916.
    - a. Hinges: 180-degree inward **OR** 180-degree outward **OR** 360-degree inward and outward, **as directed**, swing.
    - b. Latches permitting operation from one side **OR** both sides, **as directed**, of gate with provision for padlocking accessible from both sides of gate, **as directed**.
    - c. Padlock and Chain: the Owner furnished.
    - d. Lock: Manufacturer's standard, **as directed**, internal device furnished in lieu of gate latch, **as directed**.
    - e. Closer: Manufacturer's standard, **as directed**.
    - f. For gates **14 feet (4.27 m)** and higher, add locking device to transom.
- E. Horizontal-Slide Gates
  1. General: Comply with ASTM F 1184 for gate posts and single **OR** double, **as directed**, sliding gate types. Provide automated vehicular gates that comply with ASTM F 2200, **as directed**.
    - a. Classification: Type I Overhead Slide.
      - 1) Gate Leaf Width: As indicated.
      - 2) Gate Fabric Height: **72 inches (1830 mm)** or less **OR** More than **72 inches (1830 mm)** **OR** As indicated, **as directed**.
    - b. Classification: Type II Cantilever Slide, Class 1 with external **OR** Class 2 with internal, **as directed**, roller assemblies.
      - 1) Gate Frame Width and Height: **48 inches (1200 mm)** wide or less by **72 inches (1830 mm)** high or less **OR** More than **48 inches (1200 mm)** wide by any height **OR** As indicated, **as directed**.
  2. Pipe and Tubing:
    - a. Zinc-Coated Steel: Protective coating and finish to match fence framing **OR** Manufacturer's standard protective coating and finish, **as directed**.
    - b. Aluminum: Comply with ASTM B 429/B 429M; mill **OR** manufacturer's standard, **as directed**, finish.
    - c. Gate Post Size and Weight: Not less than required by ASTM F 1184 **OR** ASTM F 1916, **as directed**.
    - d. Gate Frames and Bracing: Round tubular steel **OR** Rectangular tubular steel **OR** Round tubular aluminum **OR** Rectangular tubular aluminum, **as directed**.
  3. Frame Corner Construction: Welded **OR** Assembled with corner fittings, **as directed**, and **3/8-inch- (9.5-mm-)** diameter, adjustable truss rods for panels **5 feet (1.52 m)** or wider.
  4. Extended Gate Posts and Frame Members: Extend above top of chain-link fabric at both ends of gate frame **12 inches (300 mm)** **OR** as indicated, **as directed**, as required to attach barbed wire **OR** tape, **as directed**, assemblies.
  5. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.
  6. Hardware:
    - a. Latches permitting operation from one side **OR** both sides, **as directed**, of gate with provision for padlocking accessible from both sides of gate, **as directed**.
    - b. Padlock and Chain: the Owner furnished.
    - c. Lock: Manufacturer's standard, **as directed**, internal device furnished in lieu of gate latch, **as directed**.
    - d. Hangers, roller assemblies, and stops fabricated from galvanized steel **OR** galvanized malleable iron **OR** mill-finished Grade 319 aluminum-alloy casting with stainless-steel fasteners, **as directed**.
- F. Fittings
  1. General: Comply with ASTM F 626.
  2. Post Caps: Provide for each post.
    - a. Provide line post caps with loop to receive tension wire or top rail.



3. Rail and Brace Ends: For each gate, corner, pull, and end post.
  4. Rail Fittings: Provide the following:
    - a. Top-Rail Sleeves: Pressed steel or round steel tubing not less than **6 inches (152 mm)** long.
    - b. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom, **as directed**, rails in the fence line to line posts.
  5. Tension and Brace Bands, Tension Bars, and Truss Rod Assemblies: Comply with ASTM F 2611.
  6. Barbed Wire Arms: Pressed steel or cast iron **OR** Aluminum, **as directed**, with clips, slots, or other means for attaching strands of barbed wire, and means for attaching to posts **OR** integral with post cap, **as directed**; for each post unless otherwise indicated, and as follows:
    - a. Provide line posts with arms that accommodate top rail or tension wire.
    - b. Provide corner arms at fence corner posts, unless extended posts are indicated.
    - c. Type I, single slanted arm.
    - d. Type II, single vertical arm.
    - e. Type III, V-shaped arm.
    - f. Type IV, A-shaped arm.
    - g. Bolts or rivets for connection to post.
  7. Tie Wires, Clips, and Fasteners: Comply with ASTM F 626 and ASTM F 1916.
    - a. High-Security Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:
      - 1) Metallic-Coated Steel: **0.148-inch- (3.76-mm-) OR 0.192-inch- (4.88-mm-), as directed**, diameter wire; zinc **OR** aluminum, **as directed**, coating.
      - 2) Stainless steel.
  8. Power-Driven Fabric Fasteners: Comply with ASTM F 1916.
  9. Finish:
    - a. Metallic Coating for Pressed Steel or Cast Iron: Not less than **1.2 oz. /sq. ft. (366 g/sq. m)** of zinc.
      - 1) Polymer coating over metallic coating.
    - b. Aluminum: Mill finish.
- G. Barbed Wire
1. Steel Barbed Wire: Comply with ASTM A 121, High Security Grade, for two-strand barbed wire; **0.099-inch- (2.51-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round barbs spaced not more than 3 inches (76 mm) o.c.**
    - a. Aluminum Coating: Type A.
  2. Polymer-Coated, Galvanized-Steel Barbed Wire: Comply with ASTM F 1665, Type II, for two-strand barbed wire; **0.080-inch- (2.03-mm-) diameter line wire with 0.080-inch- (2.03-mm-) diameter, four-point round aluminum-alloy OR galvanized-steel, as directed**, barbs spaced not more than **3 inches (76 mm) o.c.**
    - a. Polymer Coating: Class 1 **OR** Class 2a **OR** Class 2b, **as directed**, over aluminum **OR** zinc **OR** Zn-5-Al-MM-alloy, **as directed**, -coated steel wire.
      - 1) Color: Match chain-link fabric **OR** Dark green **OR** Olive green **OR** Brown **OR** Black **OR** As selected from manufacturer's full range, **as directed**, complying with ASTM F 934.
- H. Barbed Tape
1. Wire-Reinforced Tape: ASTM F 1910; with four-point, needle-sharp barbs permanently cold clenched around a core wire.
    - a. Core Wire: High-tensile-strength, zinc-coated steel or stainless steel.
  2. Clips: Stainless steel, **0.065 inch (1.65 mm)** thick by **0.375 inch (9.5 mm)** wide; capable of withstanding a minimum **150-lbf (667-N)** pull load to limit extension of coil, resulting in a concertina pattern when deployed.
  3. Tie Wires: Stainless steel, **0.065 inch (1.65 mm)** in diameter.

4. Fabrication: Continuous coils of barbed tape as defined in ASTM F 1379 for the following characteristics:
    - a. Configuration: Single **OR** Double, **as directed**, coil.
    - b. Style: Helical **OR** Concertina, **as directed**, pattern.
    - c. Coil Diameter(s): **18 inches (457 mm) OR 24 inches (610 mm) OR 24-inch (610-mm)** inner coil and **30-inch (762-mm)** outer coil **OR** As indicated on Drawings, **as directed**.
    - d. Coil Loop Spacing(s): **12 inches (305 mm) OR** Manufacturer's standard **OR** As indicated on Drawings, **as directed**.
    - e. Barb Length Classification: Long, **1.2-inch (30.5-mm) OR** Medium, **0.4-inch (10.2-mm) OR** Short, **0.1875-inch (4.76-mm)**, **as directed**, barb.
    - f. Barb Spacing: **4 inches (102 mm)** o.c.
    - g. Barb Set: Straight **OR** Offset **OR** Manufacturer's standard, **as directed**.
  5. Ground Barrier Stakes: **3/8-inch- (9.5-mm-)** diameter galvanized reinforcing bar, **18 inches (457 mm)** long with 180-degree end hook **3-1/2 inches (89 mm)** long.
- I. Gate Operators
1. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
    - a. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
    - b. Provide operator with UL approval **OR** UL-approved components, **as directed**.
    - c. Provide electronic components with built-in troubleshooting diagnostic feature.
    - d. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.
  2. Comply with NFPA 70.
  3. UL Standard: Manufacturer and label gate operators to comply with UL 325.
  4. Motor Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, within installed environment, with indicated operating sequence, and without exceeding nameplate rating or considering service factor. Comply with NEMA MG 1 and the following:
    - a. Voltage: 12-V dc **OR** 120 V **OR** 208-220 V **OR** NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected, **as directed**.
    - b. Horsepower: 1/4 **OR** 1/3 **OR** 3/4, **as directed**.
    - c. Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.
    - d. Duty: Continuous duty at ambient temperature of **105 deg F (40 deg C)** and at altitude of **3300 feet (1005 m)** above sea level.
    - e. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
    - f. Phase: One **OR** Polyphase, **as directed**.
  5. Gate Operators: Gate **OR** Equipment base/pad **OR** Pedestal post **OR** In ground, **as directed**, mounted and as follows:
    - a. Hydraulic Swing **OR** Slide, **as directed**, Gate Operators:
      - 1) Duty: Medium **OR** Heavy, **as directed**.
      - 2) Gate Speed: Minimum **45 feet (13.7 m) OR 60 feet (18.2 m)**, **as directed**, per minute.
      - 3) Maximum Gate Weight: **800 lb (363 kg)**.
      - 4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** Continuous duty, **as directed**.
      - 5) Operating Type: Wheel and rail drive with manual release, **as directed**.
      - 6) Hydraulic Fluid: Of viscosity required for gate operation at ambient temperature range for Project.
      - 7) Locking: Hydraulic in both directions.
      - 8) Heater: Manufacturer's standard track and roller heater with thermostatic control.
    - b. Mechanical Swing **OR** Slide, **as directed**, Gate Operators:
      - 1) Duty: Medium **OR** Heavy **OR** Maximum security, **as directed**.

- 2) Gate Speed: Minimum **45 feet (13.7 m)** per minute **OR** **60 feet (18.2 m)** per minute **OR** variable speed, **as directed**.
  - 3) Maximum Gate Weight: **800 lb (363 kg)** **OR** **3000 lb (1360 kg)**, **as directed**.
  - 4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** 60 cycles per hour **OR** Continuous duty, **as directed**.
  - 5) Operating Type: Crank arm **OR** Enclosed **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
  - 6) Drive Type: Enclosed worm gear and chain-and-sprocket, **as directed**, reducers, roller-chain drive.  
**OR**  
Drive Type: V-belt and worm gear **OR** chain-and-sprocket, **as directed**, reducers, roller-chain drive.
6. Remote Controls: Electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 **OR** NEMA ICS 6, Type 4, **as directed**, enclosure for surface **OR** recessed or flush **OR** equipment base/pad **OR** pedestal, **as directed**, mounting and with space for additional optional equipment. Provide the following remote-control device(s):
- a. Control Station: Keyed, two **OR** three, **as directed**, -position switch, located remotely from gate. Provide two keys per station.  
**OR**  
Control Station: Momentary contact, single **OR** three, **as directed**, -button operated, located remotely from gate. Key switch to lock out open and close buttons, **as directed**.
    - 1) Function: Open, stop, **as directed**, and close.
  - b. Card Reader: Functions only when authorized card is presented. Programmable, magnetic multiple **OR** single, **as directed**, -code system, permitting four different access time periods, **as directed**; face-lighted unit fully visible at night, **as directed**.
    - 1) Reader Type: Touch plate **OR** Swipe **OR** Insertion **OR** Proximity, **as directed**.
    - 2) Features: Timed anti-passback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
  - c. Digital Keypad Entry Unit: Multiple-code capability **OR** Multiple-programmable code capability, **as directed**, of not less than five **OR** 500 **OR** 2500, **as directed**, possible individual codes, consisting of one- to seven **OR** four **OR** five, **as directed**, -digit codes and permitting four different access time periods, **as directed**.
    - 1) Features: Timed anti-passback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
    - 2) Face-lighted unit with metal-keyed **OR** keyless-membrane, **as directed**, keypad fully visible at night.
  - d. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide one **OR** two, **as directed**, programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than 1000 **OR** 10,000, **as directed**, codes per channel configured for the following functions:
    - 1) Transmitters: Single **OR** Three, **as directed**, -button operated, with open **OR** open and close, **as directed**, function.
    - 2) Channel Settings: Two **OR** Three **OR** Four, **as directed**, independent channel settings controlling separate receivers for operating more than one gate from each transmitter.
  - e. Telephone Entry System: Hands-free voice-communication system for connection to building telephone system with digital-entry code activation of gate operator and auxiliary keypad entry, **as directed**.
    - 1) System: Designed to be wired to same line with telephone.  
**OR**  
Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access 20 **OR** 100, **as directed**, telephones and with electronic directory, **as directed**.

- f. Vehicle Loop Detector: System including automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and loop detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, as recommended in writing by detection system manufacturer for function indicated.
  - 1) Loop: Wire, in size indicated for field assembly, for pave-over **OR** saw-cut with epoxy-grouted, **as directed**, installation.  
**OR**  
Loop: Factory preformed in size indicated; style for pave-over **OR** saw-cut with epoxy-grouted, **as directed**, installation.
- g. Vehicle Presence Detector: System including automatic closing timer with adjustable time delay before closing, timer cut-off switch, **as directed**, and presence detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide retroreflective **OR** emitter/receiver, **as directed**, detector with adjustable detection zone pattern and sensitivity, designed to detect presence or transit of a vehicle in gate pathway when an infrared beam in zone pattern is interrupted, and to emit a signal activating the gate operator.
7. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
  - a. Action: Reverse gate in both opening and closing cycles and hold until clear of obstruction **OR** Stop gate in opening cycle and reverse gate in closing cycle and hold until clear of obstruction, **as directed**.
  - b. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
  - c. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as follows. Connect to control circuit using take-up cable reel **OR** self-coiling cable **OR** gate edge transmitter and operator receiver system, **as directed**.
    - 1) Along entire gate leaf leading edge (for swing gates and slide gates).
    - 2) Along entire gate leaf trailing edge (for slide gates).
    - 3) Across entire gate leaf bottom edge (for vehicular swing and slide gates complying with UL 325 or to suit Project; consider retaining for pedestrian gates).
    - 4) Along entire length of gate posts (for slide gates; revise for sensor edge at pinch point post of swing gates).
    - 5) Along entire length of gate guide posts (for Type II Cantilever Slide, Class 1 gates).
    - 6) Where indicated on Drawings.
  - d. Photoelectric/Infrared Sensor: System designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.
8. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully retracted and fully extended positions.
9. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type of mechanism, permitting manual operation if operator fails. Design system so control circuit power is disconnected during manual operation.
  - a. Type: Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge **OR** Mechanical device, key, or crank-activated release, **as directed**.
10. Operating Features:
  - a. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features with capability of monitoring and auditing gate activity, **as directed**. Provide unit that is isolated from voltage spikes and surges.
  - b. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
  - c. Master/Slave Capability: Control stations designed and wired for gate pair operation.



- d. Automatic Closing Timer: With adjustable time delay before closing and timer cut-off switch, **as directed**.
- e. Open Override Circuit: Designed to override closing commands.
- f. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
- g. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
- h. Clock Timer: 24-hour **OR** Seven-day, **as directed**, programmable for regular events.
- 11. Accessories:
  - a. Warning Module: Audio **OR** Visual, **as directed**, constant **OR** strobe, **as directed**, light alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving; compliant with the U.S. Architectural & Transportation Barriers Compliance Board's ADA-ABA Accessibility Guidelines.
  - b. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system.
    - 1) Fail Safe: Gate opens and remains open until power is restored.
    - 2) Fail Secure: Gate cycles on battery power, then fail safe when battery is discharged.
  - c. External electric-powered solenoid **OR** magnetic, **as directed**, lock with delay timer allowing time for lock to release before gate operates.
  - d. Fire **OR** Postal, **as directed**, box.
  - e. Fire strobe **OR** siren, **as directed**, sensor.
  - f. Intercom System: As required to meet Project requirements.
  - g. Instructional, Safety, and Warning Labels and Signs: According to UL 325 **OR** Manufacturer's standard for components and features specified **OR** As indicated on Drawings, **as directed**.
  - h. Equipment Bases/Pads: Precast concrete, depth not less than **12 inches (305 mm)**, dimensioned and reinforced according to gate operator component manufacturer's written instructions and as indicated on Drawings.
- J. Grout And Anchoring Cement
  - 1. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107. Provide grout, recommended in writing by manufacturer, for exterior applications.
  - 2. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound. Provide formulation that is resistant to erosion from water exposure without needing protection by a sealer or waterproof coating and that is recommended in writing by manufacturer for exterior applications.
- K. Fence Grounding
  - 1. Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
    - a. Material above Finished Grade: Copper **OR** Aluminum, **as directed**.
    - b. Material on or below Finished Grade: Copper.
    - c. Bonding Jumpers: Braided copper tape, **1 inch (25.4 mm)** wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
  - 2. Connectors and Grounding Rods: Listed in UL 467.
    - a. Connectors for Below-Grade Use: Exothermic welded type.
    - b. Grounding Rods: Copper-clad steel, **5/8 by 96 inches (16 by 2440 mm)**.
- L. Soil Sterilization
  - 1. Soil Sterilant: Type approved by authorities having jurisdiction.
  - 2. Polyethylene Sheeting: **6 mils (0.15 mm)** thick, black, and serving as soil separation fabric.
  - 3. Stone Ground Cover: **3/4- to 2-inch (19- to 51-mm)** crushed stone or washed gravel.



### 1.3 EXECUTION

#### A. Examination

1. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, **as directed**, site clearing, earthwork, pavement work, and other conditions affecting performance of the Work.
  - a. Do not begin installation before final grading is completed unless otherwise permitted by the Owner.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Preparation

1. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of **500 feet (152 m)** or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

#### C. Installation, General

1. Install chain-link fencing to comply with ASTM F 567 **OR** ASTM F 1916, **as directed**, and more stringent requirements specified.
  - a. Install fencing on established boundary lines inside property line.

#### D. Chain-Link Fence Installation

1. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
2. Post Setting: Set posts in concrete **OR** with mechanical anchors **OR** by mechanically driving into soil, **as directed**, at indicated spacing into firm, undisturbed soil.
  - a. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
  - b. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
    - 1) Exposed Concrete: Extend **2 inches (51 mm)** above grade or to same elevation as concrete grade beam, **as directed**; shape and smooth to shed water.
    - 2) Concealed Concrete: Top **2 inches (51 mm)** below grade as indicated on Drawings to allow covering with surface material.
    - 3) Posts Set into Concrete in Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout **OR** anchoring cement, **as directed**, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
    - 4) Posts Set into Voids in Concrete: Form or core drill holes not less than **5 inches (127 mm)** deep and **3/4 inch (19 mm)** larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout **OR** anchoring cement, **as directed**, mixed and placed to comply with anchoring material manufacturer's written instructions, and finished sloped to drain water away from post.
3. Terminal Posts: Locate and install terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of 15 degrees or more, at any abrupt change in grade, and at intervals not greater than **500 feet (152 m)**. For runs exceeding **500 feet (152 m)**, space pull posts an equal distance between corner or end posts.
4. Line Posts: Space line posts uniformly at **96 inches (2440 mm)** **OR** **10 feet (3 m)**, **as directed**, o.c.
5. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Diagonally brace terminal posts to adjacent line posts with truss rods and turnbuckles. Install braces at end and gate posts and at both sides of corner and pull posts.

- a. Locate horizontal braces at midheight of fabric **72 inches (1830 mm)** or higher, on fences with top rail and at two-third fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
6. Barbed Wire Arms: Bolt or rivet to top of post. Angle single arms away from approach side of fence.
7. Tension Wire: Install according to ASTM F 567 and ASTM F 1916, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with **0.120-inch- (3.05-mm-)** diameter hog rings of same material and finish as fabric wire, spaced a maximum of **24 inches (610 mm)** o.c. Install tension wire in locations indicated before stretching fabric. Provide horizontal tension wire at the following locations:
  - a. Extended along top and bottom, **as directed**, of fence fabric. Install top tension wire through post cap loops. Install bottom tension wire within **6 inches (152 mm)** of bottom of fabric and tie to each post with not less than same diameter and type of wire.
  - b. Extended along top of barbed wire arms **OR** extended posts, **as directed**, and top of fence fabric for supporting barbed tape.
  - c. As indicated.
8. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended by fencing manufacturer.
9. Bottom Rails: Install and secure to posts with fittings; anchor rail at midspan to concrete footing **OR** continuous grade beam, **as directed**.
10. Chain-Link Fabric: Apply fabric on the approach side of fence, inside of enclosing framework. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
  - a. Leave **1-1/2 inches (38 mm) OR 2 inches (51 mm)**, **as directed**, between finish grade or surface and bottom selvage unless otherwise indicated.
  - b. Where indicated, bury an **18-inch- (457-mm-)** wide, polymer-coated fabric **12 inches (305 mm)** into trench; overlap above-grade fabric **6 inches (152 mm)** and secure to bottom rail with tie wires. Backfill and compact trench.
  - c. Overlapping Fabric: At or between post or rail according to ASTM F 1916, with wire ties or steel strap method.
11. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than **15 inches (381 mm)** o.c.
12. Tie Wires: Power-fastened or manually fastened ties configured to wrap a full 360 degrees around rail or post and a minimum of one complete diamond of fabric. Twist ends one and one-half machine twists or three full manual twists, and cut off protruding ends to preclude untwisting by hand.
  - a. Maximum Spacing: Tie fabric to line posts at **12 inches (305 mm)** o.c. and to braces at **24 inches (610 mm)** o.c.
13. Power-Driven Fasteners: Fasten **0.192- or 0.148-inch (4.87- or 3.76-mm)** wire fabric with **2- or 1-inch (51- or 25.4-mm)** mesh size.
  - a. Fasten fabric to line posts **12 inches (305 mm)** o.c. and to braces **24 inches (610 mm)** o.c.
14. Fasteners: Install nuts for tension bands and carriage bolts on the side of fence opposite the fabric side. Peen ends of bolts or score threads to prevent removal of nuts, **as directed**.
15. Barbed Wire: Install barbed wire uniformly spaced as indicated on Drawings **OR** as directed. Pull wire taut, install securely to extension arms, and secure to end post or terminal arms.
16. Barbed Tape: Comply with ASTM F 1911. Install barbed tape uniformly in configurations indicated and fasten securely to prevent movement or displacement.
17. Ground Barrier Stakes: Stake coils at **10 feet (3 m)** o.c., driven to full depth.

#### E. Gate Installation

1. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-

resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

F. Gate Operator Installation

1. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.
2. Excavation for Support Posts **OR** Pedestals **OR** Equipment Bases/Pads, **as directed**: Hand-excavate holes for bases/pads, in firm, undisturbed soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated.
3. Vehicle Loop Detector System: Cut grooves in pavement and bury **OR** Bury, **as directed**, and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.
4. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

G. Grounding And Bonding

1. Fence Grounding: Install at maximum intervals of **100 feet (30 m)** except as follows:
  - a. Gates and Other Fence Openings: Ground fence on each side of opening.
    - 1) Bond metal gates to gate posts.
    - 2) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least **18 inches (457 mm)** below finished grade.
2. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of **150 feet (45 m)** on each side of crossing.
3. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
4. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is **6 inches (152 mm)** below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location, including the following:
  - a. Make grounding connections to each barbed wire strand with wire-to-wire connectors designed for this purpose.
  - b. Make grounding connections to each barbed tape coil with connectors designed for this purpose.
5. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
6. Connections: Make connections to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
  - a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
  - b. Make connections with clean, bare metal at points of contact.
  - c. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
  - d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
  - e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
7. Bonding to Lightning Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning protection down conductor or lightning protection grounding conductor complying with NFPA 780.

H. Soil Sterilization

1. General: Comply with ASTM F 1916.
2. Apply sterilant after completing grounding and other below-grade electrical work along fence line and within zone between double-row chain-link fence installation.



3. Install soil separation fabric continuously between double-row chain-link fence installation, overlapping punctures and joints **6 inches (152 mm)**.
4. Lay continuous **3-inch- (75-mm-)** deep bed of crushed stone or washed gravel over soil separation fabric.
5. Extend soil sterilization **4 feet (1.2 m) OR 6 feet (1.8 m)**, **as directed**, beyond outside and inside of fence.

I. Field Quality Control

1. Fabric Testing: Test fabric tension according to ASTM F 1916.
2. Fence Post Rigidity Testing: Test line posts for rigidity according to ASTM F 1916.
3. Grounding-Resistance Testing: Engage a qualified testing agency to perform tests and inspections.
  - a. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance no fewer than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
  - b. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify the Owner promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
  - c. Report: Prepare test reports, certified by testing agency, of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

J. Adjusting

1. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.
2. Automatic Gate Operator: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, alarms, **as directed**, and limit switches.
  - a. Hydraulic Operator: Purge operating system, adjust pressure and fluid levels, and check for leaks.
  - b. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
  - c. Test and adjust controls, alarms, **as directed**, and safeties. Replace damaged and malfunctioning controls and equipment.
3. Lubricate hardware, gate operator, **as directed**, and other moving parts.

K. Demonstration

1. Train the Owner's personnel to adjust, operate, and maintain high-security chain-link fences and gates.

END OF SECTION 32 31 13 13



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Task	Specification	Specification Description
32 31 13 13	01 22 16 00	No Specification Required
32 31 13 13	31 13 13 00	Tree Protection And Trimming
32 31 13 13	32 31 11 00	Chain-Link Fences And Gates

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## SECTION 32 31 19 00 - ORNAMENTAL METAL FENCES AND GATES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of ornamental metal fences and gates. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Decorative metallic-coated steel tubular picket fences.
  - b. Decorative metallic-coated steel wire fences.
  - c. Decorative metallic-coated steel security fences.
  - d. Decorative steel fences.
  - e. Decorative aluminum fences.
  - f. Swing gates.
  - g. Horizontal-slide gates.
  - h. Gate operators, including controls.

#### C. Performance Requirements

1. Lightning-Protection System: Maximum grounding-resistance value of 25 ohms under normal dry conditions.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings: For gates. Include plans, elevations, sections, details, and attachments to other work.
  - a. Wiring Diagrams: For power, signal, and control wiring.
3. Samples: For each fence material and for each color specified.
  - a. Provide Samples **12 inches (300 mm)** in length for linear materials.
  - b. Provide Samples **12 inches (300 mm)** square for wire mesh, bar grating, and sheet or plate materials.
4. Welding certificates.
5. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for decorative metallic-coated steel tubular picket fences, including finish, indicating compliance with referenced standard and other specified requirements.
6. Maintenance Data: For gate operators to include in maintenance manuals.

#### E. Quality Assurance

1. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel **OR** AWS D1.2/D1.2M, "Structural Welding Code - Aluminum", **as directed**.
2. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. UL Standard: Provide gate operators that comply with UL 325.
4. Emergency Access Requirements: Comply with requirements of authorities having jurisdiction for automatic gate operators on gates that must provide emergency access.
5. Preinstallation Conference: Conduct conference at Project site.

## 1.2 PRODUCTS

### A. Aluminum

1. Aluminum, General: Provide alloys and tempers with not less than the strength and durability properties of alloy and temper designated in paragraphs below for each aluminum form required.
2. Extrusions: **ASTM B 221 (ASTM B 221M)**, Alloy 6063-T5.
3. Tubing: ASTM B 429, Alloy 6063-T6.
4. Plate and Sheet: **ASTM B 209 (ASTM B 209M)**, Alloy 6061-T6.
5. Die and Hand Forgings: **ASTM B 247 (ASTM B 247M)**, Alloy 6061-T6.
6. Castings: ASTM B 26/B 26M, Alloy A356.0-T6.

### B. Steel And Iron

1. Plates, Shapes, and Bars: ASTM A 36/A 36M.
2. Bars (Pickets): Hot-rolled, carbon steel complying with ASTM A 29/A 29M, Grade 1010.
3. Tubing: ASTM A 500, cold formed steel tubing.
4. Bar Grating: NAAMM MBG 531.
  - a. Bars: Hot-rolled steel strip, ASTM A 1011/A 1011M, Commercial Steel, Type B.
  - b. Wire Rods: **ASTM A 510 (ASTM A 510M)**.
5. Uncoated Steel Sheet: Hot-rolled steel sheet, ASTM A 1011/A 1011M, Structural Steel, **Grade 45 (Grade 310)** or cold-rolled steel sheet, ASTM A 1008/A 1008M, Structural Steel, **Grade 50 (Grade 340)**.
6. Galvanized-Steel Sheet: ASTM A 653/A 653M, structural quality, **Grade 50 (Grade 340)**, with **G90 (Z275) OR G60 (Z180)**, **as directed**, coating.
7. Aluminum-Zinc Alloy-Coated Steel Sheet: ASTM A 792/A 792M, structural quality, **Grade 50 (Grade 340)**, with **AZ60 (AZM180)** coating.
8. Castings: Either gray or malleable iron unless otherwise indicated.
  - a. Gray Iron: ASTM A 48/A 48M, Class 30.
  - b. Malleable Iron: ASTM A 47/A 47M.

### C. Coating Materials

1. Shop Primers for Steel: Provide primers that comply with Division 09 Section(s) "Exterior Painting" OR "High-performance Coatings", **as directed**.
2. Epoxy Zinc-Rich Primer for Steel: Complying with MPI #20 and compatible with coating specified to be applied over it.
  - a. Use primer with a VOC content of 420 g/L **OR** 400 g/L **OR** 340 g/L, **as directed**, or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Epoxy Primer for Galvanized Steel: Complying with MPI #101 and compatible with coating specified to be applied over it.
  - a. Use primer with a VOC content of 420 g/L **OR** 400 g/L **OR** 300 g/L, **as directed**, or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
4. Epoxy Intermediate Coat: Complying with MPI #77 and compatible with primer and topcoat.
  - a. Use product with a VOC content of 420 g/L **OR** 400 g/L **OR** 250 g/L, **as directed**, or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Polyurethane Topcoat: Complying with MPI #72 and compatible with undercoat.
  - a. Use product with a VOC content of 420 g/L **OR** 400 g/L **OR** 250 g/L, **as directed**, or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

### D. Miscellaneous Materials

1. Welding Rods and Bare Electrodes: Select according to AWS specifications for metal alloy welded.
  - a. For aluminum, provide type and alloy as recommended by producer of metal to be welded and as required for strength and compatibility in fabricated items.
2. Concrete: Normal-weight, air-entrained, ready-mix concrete complying with requirements in Division 03 Section "Miscellaneous Cast-in-place Applications) Concrete" with a minimum 28-day compressive strength of **3000 psi (20 MPa)**, **3-inch (75-mm)** slump, and **1-inch (25-mm)**

- maximum aggregate size or dry, packaged, normal-weight concrete mix complying with ASTM C 387 mixed with potable water according to manufacturer's written instructions.
3. Nonshrink Grout: Factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107 and specifically recommended by manufacturer for exterior applications.
- E. Grounding Materials
1. Grounding Conductors: Bare, solid wire for No. 6 AWG and smaller; stranded wire for No. 4 AWG and larger.
    - a. Material above Finished Grade: Copper **OR** Aluminum, **as directed**.
    - b. Material on or below Finished Grade: Copper.
    - c. Bonding Jumpers: Braided copper tape, **1 inch (25 mm)** wide, woven of No. 30 AWG bare copper wire, terminated with copper ferrules.
  2. Grounding Connectors and Grounding Rods: Comply with UL 467.
    - a. Connectors for Below-Grade Use: Exothermic-welded type.
    - b. Grounding Rods: Copper-clad steel.
      - 1) Size: **5/8 by 96 inches (16 by 2440 mm)**.
- F. Decorative Metallic-Coated Steel Tubular Picket Fences
1. Decorative Metallic-Coated Steel Tubular Picket Fences: Comply with ASTM F 2408, for residential **OR** light industrial (commercial) **OR** industrial, **as directed**, application (class) unless otherwise indicated.
  2. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc alloy-coated steel sheet.
  3. Interior surface of tubes formed from uncoated steel sheet shall be hot-dip zinc coated same as exterior or coated with zinc-rich thermosetting coating to comply with ASTM F 2408.
  4. Posts:
    - a. End and Corner Posts: Square tubes **2-1/2 by 2-1/2 inches (64 by 64 mm) OR 3 by 3 inches (76 by 76 mm)**, **as directed**, formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
    - b. Swing Gate Posts:
      - 1) Square tubes **3 by 3 inches (76 by 76 mm)** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.  
**OR**  
Square steel tubing **3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm)**, **as directed**, with **3/16-inch (4.76-mm)** wall thickness, hot-dip galvanized.
    - c. Horizontal-Slide Gate Post, Openings up to **12 Feet (3.7 m)**: Square steel tubing **3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm)**, **as directed**, with **3/16-inch (4.76-mm)** wall thickness, hot-dip galvanized.
    - d. Horizontal-Slide Gate Post, Openings Wider Than **12 Feet (3.7 m)**: Square steel tubing **4 by 4 inches (102 by 102 mm)** with **3/16-inch (4.76-mm)** wall thickness, hot-dip galvanized.
    - e. Guide Posts for Class 1 Horizontal-Slide Gates:
      - 1) Square tubes **3 by 3 inches (76 by 76 mm)** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication; installed adjacent to gate post to permit gate to slide in space between.  
**OR**  
Square steel tubing **3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm)**, **as directed**, with **3/16-inch (4.76-mm)** wall thickness, hot-dip galvanized; installed adjacent to gate post to permit gate to slide in space between.
  5. Post Caps: Formed from steel sheet and hot-dip galvanized after forming **OR** UV-resistant plastic **OR** Aluminum castings **OR** Aluminum castings with round ball finials, **as directed**.
  6. Rails: Square tubes **OR** Double-wall channels, **as directed**.
    - a. Size: **1-1/2 by 1-1/2 inches (38 by 38 mm) OR 1-3/4 by 1-3/4 inches (45 by 45 mm)**, **as directed**.

- b. Metal and Thickness: **0.079-inch (2.01-mm)** nominal-thickness, metallic-coated steel sheet or **0.075-inch (1.90-mm)** nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
  7. Pickets: Square tubes.
    - a. Terminate tops of pickets at top rail for flush top appearance **OR** Extend pickets beyond top rail as indicated and terminate with UV-resistant plastic caps **OR** Extend pickets beyond top rail as indicated and terminate with galvanized-steel caps **OR** Extend pickets beyond top rail as indicated and press flat and trim to produce spear point shape, **as directed**.
    - b. Picket Spacing: **6 inches (152.4 mm)** **OR** **4 inches (101.6 mm)** **OR** **1-3/4 inches (44 mm)**, **as directed**, clear, maximum.
  8. Fasteners: Manufacturer's standard concealed fastening system.
  9. Fasteners: Manufacturer's standard tamperproof, **as directed**, corrosion-resistant, color-coated fasteners matching fence components, with resilient polymer washers, **as directed**.
  10. Galvanizing: For components indicated to be galvanized and for which galvanized coating is not specified in ASTM F 2408, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
  11. Finish: Organic coating complying with requirements in ASTM F 2408 **OR** Powder coating, **as directed**.
- G. Decorative Metallic-Coated Steel Wire Fences
  1. Metallic-Coated Steel Wire: Welded-wire fence fabric, hot-dip galvanized after fabrication. Weight of zinc coating shall be not less than **1.0 oz./sq. ft. (305 g/sq. m)**.
    - a. Spacing of Vertical Wires: **1-3/4 inches (44 mm)** **OR** **2 inches (51 mm)** **OR** **3-1/2 inches (89 mm)** **OR** **4 inches (102 mm)** **OR** As indicated, **as directed**.
    - b. Vertical Wire Size: **0.187 inch (4.76 mm)** **OR** **0.192 inch (4.88 mm)** **OR** **0.225 inch (5.72 mm)** **OR** **0.25 inch (6.35 mm)** **OR** **0.262 inch (6.67 mm)**, **as directed**.
    - c. Spacing of Horizontal Wires: **1-3/4 inches (44 mm)** **OR** **2 inches (51 mm)** **OR** **4 inches (102 mm)** **OR** **8 inches (203 mm)** **OR** As indicated, **as directed**.
    - d. Horizontal Wire Size: **0.187 inch (4.76 mm)** **OR** **0.192 inch (4.88 mm)** **OR** **0.225 inch (5.72 mm)** **OR** **0.25 inch (6.35 mm)** **OR** **0.312 inch (7.94 mm)**, **as directed**.
  2. Metallic-Coated Steel Sheet: Galvanized-steel sheet or aluminum-zinc alloy-coated steel sheet.
  3. Interior surface of tubes formed from uncoated steel sheet shall be hot-dip zinc coated same as exterior or coated with zinc-rich thermosetting coating to comply with ASTM F 2408.
  4. Posts:
    - a. Line Posts: Square tubes **2 by 2 inches (50 by 50 mm)** **OR** **2-1/2 by 2-1/2 inches (64 by 64 mm)** **OR** **3 by 3 inches (76 by 76 mm)**, **as directed**, formed from **0.064-inch (1.63-mm)** **OR** **0.079-inch (2.01-mm)** **OR** **0.108-inch (2.74-mm)**, **as directed**, nominal-thickness, metallic-coated steel sheet or formed from **0.060-inch (1.52-mm)** **OR** **0.075-inch (1.90-mm)** **OR** **0.105-inch (2.66-mm)**, **as directed**, nominal-thickness steel sheet and hot-dip galvanized after fabrication.
    - b. End and Corner Posts: Square tubes **2-1/2 by 2-1/2 inches (64 by 64 mm)** **OR** **3 by 3 inches (76 by 76 mm)**, **as directed**, formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
    - c. Swing Gate Posts:
      - 1) Square tubes **3 by 3 inches (76 by 76 mm)** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.  
**OR**  
Square steel tubing **3 by 3 inches (76 by 76 mm)** **OR** **4 by 4 inches (102 by 102 mm)**, **as directed**, with **3/16-inch (4.76-mm)** wall thickness, hot-dip galvanized.
    - d. Horizontal-Slide Gate Post, Openings up to **12 Feet (3.7 m)**: Square steel tubing **3 by 3 inches (76 by 76 mm)** **OR** **4 by 4 inches (102 by 102 mm)**, **as directed**, with **3/16-inch (4.76-mm)** wall thickness, hot-dip galvanized.



- e. Horizontal-Slide Gate Post, Openings Wider Than **12 Feet (3.7 m)**: Square steel tubing **4 by 4 inches (102 by 102 mm)** with **3/16-inch (4.76-mm)** wall thickness, hot-dip galvanized.
  - f. Guide Posts for Class 1 Horizontal-Slide Gates:
    - 1) Square tubes **3 by 3 inches (76 by 76 mm)** formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication; installed adjacent to gate post to permit gate to slide in space between.  
**OR**  
Square steel tubing **3 by 3 inches (76 by 76 mm)** **OR 4 by 4 inches (102 by 102 mm)**, **as directed**, with **3/16-inch (4.76-mm)** wall thickness, hot-dip galvanized; installed adjacent to gate post to permit gate to slide in space between.
  5. Post Caps: Formed from steel sheet and hot-dip galvanized after forming **OR** UV-resistant plastic **OR** Aluminum castings **OR** Aluminum castings with round ball finials, **as directed**.
  6. Rails: Square tubes.
    - a. Size: **1-3/16 by 1-1/2 inches (30 by 38 mm)** **OR 1-3/8 by 1-1/2 inches (35 by 38 mm)** **OR 1-1/2 by 1-1/2 inches (38 by 38 mm)**, **as directed**.
    - b. Metal and Thickness: **0.064-inch (1.63-mm)** **OR 0.079-inch (2.01-mm)**, **as directed**, nominal-thickness, metallic-coated steel sheet or **0.060-inch (1.52-mm)** **OR 0.075-inch (1.90-mm)**, **as directed**, nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
  7. Fasteners: Manufacturer's standard tamperproof, **as directed**, corrosion-resistant, color-coated fasteners matching fence components with resilient polymer washers or clips, **as directed**.
  8. Galvanizing: For components indicated to be galvanized and for which galvanized coating is not specified, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
  9. Finish: Organic coating complying with requirements in ASTM F 2408 **OR** Powder coating, **as directed**.
- H. Decorative Metallic-Coated Steel Security Fences
1. Posts: **1-3/4-by-4-inch (45-by-102-mm)** double-thickness, I-shaped sections.
    - a. Metal and Thickness: **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or **0.105-inch (2.66-mm)** nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
  2. Post Caps: Aluminum castings.
  3. Rails: **2-by-2-1/2-inch (50-by-64-mm)** pentagon-shaped box channel designed to shed water and to enclose wire rope reinforcement.
    - a. Metal and Thickness: **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or **0.105-inch (2.66-mm)** nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
    - b. Wire Rope Reinforcement: **3/4-inch (19-mm)** zinc-coated steel wire rope.
  4. Pickets: **3/4-by-2-3/4-inch (19-by-70-mm)** M-shaped pales.
    - a. Metal and Thickness: **0.079-inch (2.01-mm)** nominal-thickness, metallic-coated steel sheet or **0.075-inch (1.90-mm)** nominal-thickness, uncoated steel sheet, hot-dip galvanized after fabrication.
    - b. Extend pickets beyond top rail as indicated and terminate with rounded edge **OR** cut and split to form three points, **as directed**.
    - c. Picket Spacing: **6 inches (152.4 mm)** o.c.
  5. Fasteners: Stainless-steel carriage bolts with tamperproof nuts.
  6. Galvanizing: For components indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M unless otherwise indicated. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
  7. Finish: Powder coating.
- I. Decorative Steel Fences
1. Decorative Steel Fences: Fences made from steel tubing bars, **as directed**, and shapes, hot-dip galvanized, **as directed**.



2. Posts: Square steel tubing.
  - a. Line Posts: **2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm) OR 3 by 3 inches (76 by 76 mm), as directed**, with **1/8-inch (3.2-mm) OR 3/16-inch (4.76-mm), as directed**, wall thickness.
  - b. End and Corner Posts: **2-1/2 by 2-1/2 inches (64 by 64 mm) OR 3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm), as directed**, with **1/8-inch (3.2-mm) OR 3/16-inch (4.76-mm), as directed**, wall thickness.
  - c. Swing Gate Posts: **3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm), as directed**, with **3/16-inch (4.76-mm)** wall thickness.
  - d. Horizontal-Slide Gate Post, Openings up to **12 Feet (3.7 m)**: **3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm), as directed**, with **3/16-inch (4.76-mm)** wall thickness.
  - e. Horizontal-Slide Gate Post, Openings Wider Than **12 Feet (3.7 m)**: **4 by 4 inches (102 by 102 mm)** with **3/16-inch (4.76-mm)** wall thickness.
  - f. Guide Posts for Class 1 Horizontal-Slide Gates: **3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm), as directed**, with **3/16-inch (4.76-mm)** wall thickness; installed adjacent to gate post to permit gate to slide in space between.
3. Post Caps: Formed from steel sheet **OR** Formed from steel sheet and hot-dip galvanized after forming **OR** Aluminum castings **OR** Aluminum castings with round ball finials, **as directed**.
4. Rails:
  - a. Steel Tube Rails: Square steel tubing **2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm), as directed**, with **1/8-inch (3.2-mm)** wall thickness.
  - b. Steel Channel Rails: Steel channels **2 by 1 inch (50 by 25 mm) OR 1-1/2 by 3/4 inch (38 by 19 mm) OR 1-1/2 by 1/2 inch (38 by 13 mm), as directed**.
5. Pickets: **1/2-inch- (13-mm-) square steel bars OR 3/4-inch- (19-mm-) square steel bars OR** Decorative steel bars of pattern and size indicated **OR 5/8 inch (16 mm) square by 0.065-inch (1.65-mm) steel tubes OR 5/8 inch (16 mm) square by 0.083-inch (2.11-mm) steel tubes OR 3/4 inch (19 mm) square by 0.065-inch (1.65-mm) steel tubes OR 3/4 inch (19 mm) square by 0.083-inch (2.11-mm) steel tubes OR 1 inch (25 mm) square by 0.065-inch (1.65-mm) steel tubes OR 1 inch (25 mm) square by 0.083-inch (2.11-mm) steel tubes, as directed**.
  - a. Terminate tops of pickets at top rail for flush top appearance **OR** Extend pickets beyond top rail as indicated and mill ends to pyramid shaped points **OR** Extend pickets beyond top rail as indicated and press flat and trim to produce spear point shape **OR** Extend pickets beyond top rail as indicated and cap with metal spear point finial **OR** Extend pickets beyond top rail as indicated and cap with metal tripoint finial, **as directed**.
  - b. Picket Spacing: **6 inches (152.4 mm) OR 4 inches (101.6 mm) OR 1-3/4 inches (44 mm), as directed**, clear, maximum.
  - c. Treillage: Provide iron castings of pattern indicated between each pair of pickets.
6. Infill: Forge-welded steel bar grating.
  - a. Perimeter Bars: Steel flat bars **1 by 1/8 inch (25 by 3.2 mm)**.
  - b. Vertical Main Bars: Steel flat bars **1 by 1/8 inch (25 by 3.2 mm) OR 1-3/16 by 5/32 inch (30 by 4 mm), as directed**.
  - c. Vertical Main Bar Spacing: **1-21/32 inches (42 mm) OR 1-7/8 inches (48 mm) OR 2-7/16 inches (62 mm), as directed**, o.c.
  - d. Horizontal Cross Rods: **3/16-inch- (4.8-mm-) OR 1/4-inch- (6.4-mm-), as directed**, diameter, steel rods.
  - e. Horizontal Cross Rod Spacing: **1-3/4 inches (45 mm) OR 2-19/32 inches (66 mm) OR 5-3/16 inches (132 mm), as directed**, o.c.
7. Infill: Custom design as indicated on Drawings.
  - a. Bars: **1/2-inch- (12.7 -mm-) square steel bars OR 3/4-inch- (19-mm-) square steel bars OR 1/2-inch- (12.7 -mm-) diameter, round steel bars OR 3/4-inch- (19-mm-) diameter, round steel bars OR 1-by-1/8-inch (25-by-3.2-mm) steel flat bars OR 1-by-1/4-inch (25-by-6.4-mm) steel flat bars OR 1-by-1/2-inch (25-by-12.7 -mm) steel flat bars, as directed**, unless otherwise indicated.

- b. Square Tubes: Square steel tubing **2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm)**, **as directed**, with **1/8-inch (3.2-mm)** wall thickness unless otherwise indicated.
- c. Round Tubes: **1-inch- (25-mm-) OR 1-1/2-inch- (38-mm-) OR 2-inch- (50-mm-) OR 2-1/2-inch- (64-mm-)**, **as directed**, diameter, round steel tubing with **1/8-inch (3.2-mm)** wall thickness unless otherwise indicated.
- d. Steel Plate: **1/8 inch (3.2 mm) OR 3/16 inch (4.8 mm) OR 1/4 inch (6.4 mm)**, **as directed**, thick unless otherwise indicated.
- e. Perforated Metal Sheet: Uncoated steel sheet, perforated as indicated, **0.060-inch (1.52-mm) OR 0.075-inch (1.90-mm) OR 0.105-inch (2.66-mm)**, **as directed**, nominal thickness.
8. Fasteners: Stainless-steel carriage bolts and tamperproof, **as directed**, nuts.
9. Fabrication:
  - a. Assemble fences into sections by welding pickets to rails.
    - 1) Fabricate sections with clips welded to rails for fastening to posts in field.
    - 2) Drill posts and clips for fasteners before finishing to maximum extent possible.
  - b. Fabricate bar grating infill into sections of size indicated.
    - 1) Fabricate rails with clips welded to rails for fastening to posts in field.
    - 2) Drill posts, clips, **as directed**, and bar grating for fasteners before finishing to maximum extent possible.
10. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay **OR** Finish #3 - partially dressed weld with splatter removed **OR** Finish #4 - good-quality, uniform undressed weld with minimal splatter, **as directed**.
11. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
  - a. Hot-dip galvanize posts and rails, **as directed**.
  - b. Hot-dip galvanize rail and picket assemblies after fabrication.
  - c. Hot-dip galvanize bar grating infill after fabrication.
  - d. Hot-dip galvanize custom-design rail and infill assemblies after fabrication.
12. Finish for Bar Grating Infill: Powder coating.
13. Finish for Steel Items Other than Bar Grating Infill: Primed **OR** Shop painted **OR** High-performance coating, **as directed**.
14. Finish for Metallic-Coated Steel Items Other than Bar Grating Infill: High-performance coating **OR** Galvanized finish, **as directed**.
- J. Decorative Aluminum Fences
  1. Decorative Aluminum Fences: Fences made from aluminum extrusions.
  2. Posts: Square extruded tubes.
    - a. Line Posts: **2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm) OR 3 by 3 inches (76 by 76 mm)**, **as directed**, with **0.062-inch (1.57-mm) OR 0.080-inch (2.03-mm) OR 0.093-inch (2.36-mm) OR 0.100-inch (2.54-mm) OR 0.125-inch (3.18-mm)**, **as directed**, wall thickness.
    - b. End and Corner Posts: **2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm) OR 3 by 3 inches (76 by 76 mm)**, **as directed**, with **0.062-inch (1.57-mm) OR 0.080-inch (2.03-mm) OR 0.093-inch (2.36-mm) OR 0.100-inch (2.54-mm) OR 0.125-inch (3.18-mm)**, **as directed**, wall thickness.
    - c. Swing Gate Posts: **2-1/2 by 2-1/2 inches (64 by 64 mm) OR 3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm)**, **as directed**, with **0.125-inch (3.18-mm) OR 0.250-inch (6.35-mm)**, **as directed**, wall thickness.
    - d. Horizontal-Slide Gate Post, Openings up to **12 Feet (3.7 m)**: **2-1/2 by 2-1/2 inches (64 by 64 mm) OR 3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm)**, **as directed**, with **0.125-inch (3.18-mm) OR 0.250-inch (6.35-mm)**, **as directed**, wall thickness.
    - e. Horizontal-Slide Gate Post, Openings Wider Than **12 Feet (3.7 m)**: **3 by 3 inches (76 by 76 mm) OR 4 by 4 inches (102 by 102 mm) OR 6 by 6 inches (152 by 152 mm)**, **as directed**, with **0.125-inch (3.18-mm) OR 0.250-inch (6.35-mm)**, **as directed**, wall thickness.

- f. Guide Posts for Class 1 Horizontal-Slide Gates: **2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm) OR 3 by 3 inches (76 by 76 mm), as directed**, with **0.062-inch (1.57-mm) OR 0.093-inch (2.36-mm) OR 0.125-inch (3.18-mm), as directed**, wall thickness; installed adjacent to gate post to permit gate to slide in space between.
  3. Post Caps: Aluminum castings that cover entire top of posts **OR** project at least **1/4 inch (6 mm)** beyond posts, **as directed**, with round ball finial, **as directed**.
  4. Rails: Extruded-aluminum channels, **1-1/2 by 1-1/2 inches (38 by 38 mm)**, with **0.100-inch- (2.54-mm-) thick sidewalls and 0.070-inch- (1.78-mm-) thick top OR 1 by 1-1/2 inches (25 by 38 mm)**, with **0.082-inch- (2.08-mm-) thick sidewalls and 0.055-inch- (1.40-mm-) thick top OR 1-1/4 by 1-1/4 inches (32 by 32 mm)**, with **0.078-inch- (1.98-mm-) thick sidewalls and 0.062-inch- (1.57-mm-) thick top OR 1 by 1 inch (25 by 25 mm)**, with **0.080-inch- (2.03-mm-) thick sidewalls and 0.055-inch- (1.40-mm-) thick top OR 1 by 1 inch (25 by 25 mm)**, with **0.078-inch- (1.98-mm-) thick sidewalls and 0.062-inch- (1.57-mm-) thick top, as directed**.
  5. Pickets: Extruded-aluminum tubes, **1 inch (25 mm) square**, with **0.062-inch (1.57-mm) wall thickness OR 1 inch (25 mm) square**, with **0.060-inch (1.52-mm) wall thickness OR 3/4 inch (19 mm) square**, with **0.050-inch (1.27-mm) wall thickness OR 1 by 5/8 inch (25 by 16 mm)**, with **0.050-inch (1.27-mm) wall thickness OR 5/8 inch (16 mm) square**, with **0.050-inch (1.27-mm) wall thickness, as directed**.
    - a. Terminate tops of pickets at top rail for flush top appearance **OR** Extend pickets beyond top rail as indicated and terminate with UV-resistant plastic caps **OR** Extend pickets beyond top rail as indicated and terminate with cast-aluminum caps **OR** Extend pickets beyond top rail as indicated and press flat and trim to produce spear point shape **OR** Extend pickets beyond top rail as indicated and terminate with cast-aluminum spear point finial **OR** Extend pickets beyond top rail as indicated and terminate with cast-aluminum tripoint finial, **as directed**.
    - b. Picket Spacing: **6 inches (152.4 mm) OR 4 inches (101.6 mm) OR 1-3/4 inches (44 mm), as directed**, clear, maximum.
  6. Fasteners:
    - a. Manufacturer's standard concealed fastening system.  
**OR**  
Manufacturer's standard tamperproof, **as directed**, corrosion-resistant, color-coated fasteners matching fence components with resilient polymer washers, **as directed**.
  7. Fabrication: Assemble fences into sections by welding **OR** fastening, **as directed**, pickets to rails.
    - a. Fabricate sections with clips welded to rails for fastening to posts in field.
    - b. Drill clips for fasteners before finishing.
  8. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay **OR** Finish #3 - partially dressed weld with splatter removed **OR** Finish #4 - good-quality, uniform undressed weld with minimal splatter, **as directed**.
  9. Finish: Baked enamel or powder coating.
- K. Swing Gates
1. Gate Configuration: Single leaf **OR** Double leaf, **unless directed otherwise**.
  2. Gate Frame Height: **72 inches (1830 mm), unless directed otherwise**.
  3. Gate Opening Width: **36 inches (914 mm), unless directed otherwise**.
  4. Galvanized-Steel Frames and Bracing: Fabricate members from square tubes **1-1/2 by 1-1/2 inches (38 by 38 mm) OR 1-3/4 by 1-3/4 inches (45 by 45 mm) OR 2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm), as directed**, formed from **0.108-inch (2.74-mm) nominal-thickness, metallic-coated steel sheet or formed from 0.105-inch (2.66-mm) nominal-thickness steel sheet and hot-dip galvanized after fabrication**.
  5. Steel Frames and Bracing: Fabricate members from square steel tubing **1-1/2 by 1-1/2 inches (38 by 38 mm) OR 2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm), as directed**, with **1/8-inch (3.2-mm) wall thickness**. Hot-dip galvanize frames after fabrication, **as directed**.

6. Aluminum Frames and Bracing: Fabricate members from square extruded-aluminum tubes **1-1/2 by 1-1/2 inches (38 by 38 mm) OR 2 by 2 inches (50 by 50 mm) OR 2-1/2 by 2-1/2 inches (64 by 64 mm), as directed**, with **0.100-inch (2.54-mm) OR 0.125-inch (3.18-mm) OR 0.140-inch (3.56-mm) OR 0.154-inch (3.91-mm), as directed**, wall thickness.
7. Frame Corner Construction: Welded or assembled with corner fittings and **5/16-inch- (7.9-mm-)** diameter, adjustable truss rods for panels **5 feet (1.52 m)** wide or wider.
8. Additional Rails: Provide as indicated, complying with requirements for fence rails.
9. Infill: Comply with requirements for adjacent fence.
10. Picket Size, Configuration, and Spacing: Comply with requirements for adjacent fence.
  - a. Treillage: Provide iron castings of pattern indicated between each pair of pickets. Finish as specified for adjacent fence **OR gates, as directed**.
11. Hardware: Latches permitting operation from both sides of gate, hinges, and keepers for each gate leaf more than **5 feet (1.52 m)** wide. Provide center gate stops and cane bolts for pairs of gates. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate, **as directed**.
12. Spring Hinges: BHMA A156.17, Grade 1, suitable for exterior use.
  - a. Function: 320 - Gate spring pivot hinge. Adjustable tension **OR** 321 - Gate spring pivot hinge. Fixed tension, **as directed**.
  - b. Material: Malleable iron.
13. Hinges: BHMA A156.1, Grade 1, suitable for exterior use.
  - a. Function: 39 - Full surface, triple weight, antifriction bearing.
  - b. Material: Wrought steel, forged steel, cast steel, or malleable iron.
14. Rim Locks: BHMA A156.5, Grade 1, suitable for exterior use.
  - a. Function: 621 - Latchbolt by key from outside and by turn from inside. Latchbolt is held retracted by device from inside **OR** 622 - Deadbolt by key from outside and by turn from inside **OR** 629 - Deadlocking latchbolt by key from outside and by turn from inside **OR** 626 - Interlocking deadbolt operated by key from either side **OR** 627 - Interlocking deadbolt operated by key from outside and by turn from inside, **as directed**.
  - b. Material: Cast, forged, or extruded brass or bronze.
  - c. Mounting Plate: Configuration necessary for mounting locks. Fabricate from **1/8-inch- (3.2-mm-)** thick, steel **OR** aluminum, **as directed**, plate.
15. Mortise Locks: BHMA A156.13, Grade 1, suitable for exterior use.
  - a. Function: F06 - Holdback lock **OR** F07 - Storeroom or closet lock **OR** F09 - Apartment, exit, or public toilet lock **OR** F16 - Double-cylinder dead lock **OR** F17 - Dead lock, **as directed**.
  - b. Material: Brass or bronze.
  - c. Levers: Cast, forged, or extruded brass or bronze.
  - d. Mounting Box: Configuration necessary to enclose locks. Fabricate from **1/8-inch- (3.2-mm-)** thick, steel **OR** aluminum, **as directed**, plate.
16. Electric Strikes: BHMA A156.31, Grade 1, of configuration required for use with lock specified, fail safe **OR** fail secure, **as directed**, and suitable for exterior use.
  - a. Mounting Plate: Configuration necessary for mounting electric strikes. Fabricate from **1/8-inch- (3.2-mm-)** thick, steel **OR** aluminum, **as directed**, plate.
  - b. Mounting: Mortise into post.
17. Exit Hardware: BHMA A156.3, Grade 1, Type 1 (rim exit device), with push pad actuating bar, suitable for exterior use.
  - a. Function: 01 - Exit only, no trim or blank escutcheon **OR** 04 - Entrance by trim when latch bolt is released by key or set in a retracted position by key **OR** 08 - Entrance by lever. Key locks or unlocks lever **OR** 09 - Entrance by lever only when released by key. Key removable only when locked, **as directed**.
  - b. Mounting Channel: Bent-plate channel formed from **1/8-inch- (3.2-mm-)** thick, steel **OR** aluminum, **as directed**, plate. Channel spans gate frame. Exit device is mounted on channel web, recessed between flanges, with flanges extending **1/8 inch (3.2 mm)** beyond push pad surface.
18. Cane Bolts: Provide for inactive leaf of pairs of gates. Fabricated from **1/2-inch- (12.7 -mm-) OR 3/4-inch- (19-mm-), as directed**, diameter, round steel bars, hot-dip galvanized after fabrication.



Finish to match gates. Provide galvanized-steel pipe strikes to receive cane bolts in closed position **OR** both open and closed positions, **as directed**.

19. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay **OR** Finish #3 - partially dressed weld with splatter removed **OR** Finish #4 - good-quality, uniform undressed weld with minimal splatter, **as directed**.
20. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M unless otherwise indicated. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
21. Metallic-Coated Steel Finish: High-performance coating **OR** Galvanized finish, **as directed**.
22. Steel Finish: Primed **OR** Shop painted **OR** High-performance coating, **as directed**.
23. Aluminum Finish: Baked enamel or powder coating.

**L. Horizontal-Slide Gates**

1. Gate Configuration: Single leaf **OR** Double leaf **OR** As indicated, **as directed**.
  - a. Type:
    - 1) Overhead slide.  
**OR**  
Cantilever slide, with external **OR** internal, **as directed**, roller assemblies.
2. Gate Frame Height: **72 inches (1830 mm)**, **unless directed otherwise**.
3. Gate Opening Width: **36 inches (914 mm)**, **unless directed otherwise**.
4. Galvanized-Steel Frames and Bracing: Fabricate members from square tubing.
  - a. Frame Members: Square tubes **1-1/2 by 1-1/2 inches (38 by 38 mm)** **OR** **1-3/4 by 1-3/4 inches (45 by 45 mm)** **OR** **2 by 2 inches (50 by 50 mm)** **OR** **2-1/2 by 2-1/2 inches (64 by 64 mm)**, **as directed**, formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
  - b. Bracing Members: Square tubes **1-1/2 by 1-1/2 inches (38 by 38 mm)** **OR** **1-3/4 by 1-3/4 inches (45 by 45 mm)** **OR** **2 by 2 inches (50 by 50 mm)** **OR** **2-1/2 by 2-1/2 inches (64 by 64 mm)**, **as directed**, formed from **0.108-inch (2.74-mm)** nominal-thickness, metallic-coated steel sheet or formed from **0.105-inch (2.66-mm)** nominal-thickness steel sheet and hot-dip galvanized after fabrication.
5. Steel Frames and Bracing: Fabricate members from square tubing. Hot-dip galvanize frames after fabrication, **as directed**.
  - a. Frame Members: Steel tubing **1-1/2 by 1-1/2 inches (38 by 38 mm)** **OR** **2 by 2 inches (50 by 50 mm)** **OR** **2-1/2 by 2-1/2 inches (64 by 64 mm)**, **as directed**, with **1/8-inch (3.2-mm)** wall thickness.
  - b. Bracing Members: Steel tubing **1-1/2 by 1-1/2 inches (38 by 38 mm)** **OR** **2 by 2 inches (50 by 50 mm)** **OR** **2-1/2 by 2-1/2 inches (64 by 64 mm)**, **as directed**, with **1/8-inch (3.2-mm)** wall thickness.
6. Aluminum Frames and Bracing: Fabricate members from square tubing.
  - a. Frame Members: Extruded-aluminum tubes **1-1/2 by 1-1/2 inches (38 by 38 mm)** **OR** **2 by 2 inches (50 by 50 mm)** **OR** **2-1/2 by 2-1/2 inches (64 by 64 mm)**, **as directed**, with **0.100-inch (2.54-mm)** **OR** **0.125-inch (3.18-mm)** **OR** **0.140-inch (3.56-mm)** **OR** **0.154-inch (3.91-mm)**, **as directed**, wall thickness.
  - b. Bracing Members: Extruded-aluminum tubes **1-1/2 by 1-1/2 inches (38 by 38 mm)** **OR** **2 by 2 inches (50 by 50 mm)** **OR** **2-1/2 by 2-1/2 inches (64 by 64 mm)**, **as directed**, with **0.100-inch (2.54-mm)** **OR** **0.125-inch (3.18-mm)** **OR** **0.140-inch (3.56-mm)** **OR** **0.154-inch (3.91-mm)**, **as directed**, wall thickness.
7. Frame Corner Construction:
  - a. Welded frame with panels assembled with bolted or riveted corner fittings and **5/16-inch- (7.9-mm-)** diameter, adjustable truss rods for panels **5 feet (1.52 m)** wide or wider.
  - b. Overhead Slide Gates: Welded or assembled with corner fittings including **5/16-inch- (7.9-mm-)** diameter, adjustable truss rods for panels **5 feet (1.52 m)** wide or wider.
8. Additional Rails: Provide as indicated, complying with requirements for fence rails.
9. Infill: Comply with requirements for adjacent fence.

10. Picket Size, Configuration, and Spacing: Comply with requirements for adjacent fence.
  - a. Treillage: Provide iron castings of pattern indicated between each pair of pickets. Finish as specified for adjacent fence **OR** gates, **as directed**.
11. Overhead Track Assembly: Manufacturer's standard track, with overhead framing supports, bracing, and accessories, engineered to support size, weight, width, operation, and design of gate and roller assemblies.
12. Hardware: Latches permitting operation from both sides of gate, locking devices, hangers, roller assemblies, and stops fabricated from galvanized steel **OR** galvanized malleable iron **OR** mill-finished, Grade 319 aluminum-alloy casting with stainless-steel fasteners, **as directed**. Fabricate latches with integral eye openings for padlocking; padlock accessible from both sides of gate, **as directed**.
13. Finish exposed welds to comply with NOMMA Guideline 1, Finish #2 - completely sanded joint, some undercutting and pinholes okay **OR** Finish #3 - partially dressed weld with splatter removed **OR** Finish #4 - good-quality, uniform undressed weld with minimal splatter, **as directed**.
14. Galvanizing: For items other than hardware that are indicated to be galvanized, hot-dip galvanize to comply with ASTM A 123/A 123M unless otherwise indicated. For hardware items, hot-dip galvanize to comply with ASTM A 153/A 153M.
15. Metallic-Coated Steel Finish: High-performance coating **OR** Galvanized finish, **as directed**.
16. Steel Finish: Primed **OR** Shop painted **OR** High-performance coating, **as directed**.
17. Aluminum Finish: Baked enamel or powder coating.

M. Gate Operators

1. General: Provide factory-assembled automatic operating system designed for gate size, type, weight, and operation frequency. Provide operation control system with characteristics suitable for Project conditions, with remote-control stations, safety devices, and weatherproof enclosures; coordinate electrical requirements with building electrical system.
  - a. Provide operator designed so motor may be removed without disturbing limit-switch adjustment and without affecting auxiliary emergency operator.
  - b. Provide operator with UL approval **OR** UL-approved components, **as directed**.
  - c. Provide electronic components with built-in troubleshooting diagnostic feature.
  - d. Provide unit designed and wired for both right-hand/left-hand opening, permitting universal installation.
  - e. Provide controllers, electrical devices, and wiring that comply with requirements specified in Division 22.
2. Motors: Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 11 Section "Common Motor Requirements For Equipment".
  - a. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
  - b. Horsepower: Not less than 1/4 **OR** 1/3 **OR** 1/2 **OR** 3/4, **as directed**.
  - c. Enclosure: Open dripproof **OR** Totally enclosed **OR** Manufacturer's standard, **as directed**.
  - d. Duty: Continuous duty at ambient temperature of 105 deg F (40 deg C) and at altitude of 3300 feet (1005 m) above sea level.
  - e. Service Factor: 1.15 for open dripproof motors; 1.0 for totally enclosed motors.
  - f. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 22.
3. Gate Operators: Gate **OR** Concrete base **OR** Post **OR** In-ground, **as directed**, mounted and as follows:
  - a. Hydraulic Swing **OR** Slide, **as directed**, Gate Operators:
    - 1) Duty: Light **OR** Medium **OR** Heavy, **as directed**, duty, residential **OR** commercial/industrial, **as directed**.
    - 2) Gate Speed: Minimum 45 feet (13.7 m) **OR** 60 feet (18.2 m), **as directed**, per minute.
    - 3) Maximum Gate Weight: Not to exceed operator manufacturer's recommendations.
    - 4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** Continuous duty, **as directed**.

- 5) Locking: Hydraulic in both directions.
- 6) Heater: Manufacturer's standard track and roller heater with thermostatic control, as directed.
- 7) Operating Type: Crank arm **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
- b. Mechanical Swing **OR** Slide, **as directed**, Gate Operators:
  - 1) Duty: Light **OR** Medium **OR** Heavy, **as directed**, duty, residential **OR** commercial/industrial, **as directed**.
  - 2) Gate Speed: Minimum **45 feet (13.7 m)** per minute **OR** **60 feet (18.2 m)** per minute **OR** variable speed, **as directed**.
  - 3) Maximum Gate Weight: **600 lb (272 kg)** **OR** **800 lb (363 kg)**, **as directed**.
  - 4) Frequency of Use: 10 cycles per hour **OR** 25 cycles per hour **OR** 60 cycles per hour **OR** Continuous duty, **as directed**.
  - 5) Operating Type: Crank arm **OR** Wheel and rail drive **OR** Roller chain, **as directed**, with manual release, **as directed**.
  - 6) Drive Type:
    - a) Enclosed worm gear and chain-and-sprocket, **as directed**, reducers, roller-chain drive.  
**OR**  
V-belt and worm gear **OR** chain-and-sprocket, **as directed**, reducers, roller-chain drive.
4. Remote Controls: Electric controls separated from gate and motor and drive mechanism, with NEMA ICS 6, Type 1 **OR** NEMA ICS 6, Type 4, **as directed**, enclosure for surface **OR** recessed or flush, **as directed**, concrete base **OR** pedestal, **as directed**, mounting, and with space for additional optional equipment. Provide the following remote-control device(s):
  - a. Control Station:
    - 1) Keyed, two-position **OR** three-position, **as directed**, switch with open, stop, **as directed**, and close function; located remotely from gate. Provide two keys per station.  
**OR**  
Momentary-contact, single-button-operated **OR** three-button-operated, **as directed**, with open, stop, **as directed**, and close function; located remotely from gate. Key switch to lock out open and close buttons, **as directed**.
  - b. Card Reader: Functions only when authorized card is presented. Programmable, multiple-code **OR** single-code, **as directed**, system, permitting four different access time periods, **as directed**, face-lighted unit fully visible at night, **as directed**.
    - 1) Reader Type: Touch plate **OR** Swipe **OR** Insertion **OR** Proximity, **as directed**.
    - 2) Features: Timed antipassback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
  - c. Digital Keypad Entry Unit: Multiple-programmable **OR** Multiple-code, **as directed**, capability of not less than 5 **OR** 500 **OR** 2500, **as directed**, possible individual codes, consisting of 1- to 7 **OR** 4 **OR** 5, **as directed**, -digit codes, and permitting 4 different access time periods, **as directed**.
    - 1) Features: Timed antipassback **OR** Limited-time usage **OR** Capable of monitoring and auditing gate activity, **as directed**.
    - 2) Face-lighted unit with metal-keyed **OR** keyless-membrane, **as directed**, keypad fully visible at night.
  - d. Radio Control: Digital system consisting of code-compatible universal receiver for each gate, located where indicated, with remote antenna with coaxial cable and mounting brackets designed to operate gates. Provide 1 **OR** 2, **as directed**, programmable transmitter(s) with multiple-code capability permitting validating or voiding of not less than 1000 **OR** 10,000, **as directed**, codes per channel configured for the following functions:
    - 1) Transmitters: Single **OR** Three, **as directed**, -button operated, with open and close, **as directed**, function.

- 2) Channel Settings: Two **OR** Three **OR** Four, **as directed**, independent channel settings controlling separate receivers for operating more than one gate from each transmitter.
- e. Telephone Entry System: Hands-free, voice-communication system for connection to building telephone system with digital-entry code activation of gate operator and auxiliary keypad entry, **as directed**.
  - 1) Residential System: Designed to be wired to same line with telephone.
  - 2) Multiunit System: Designed to be wired to a dedicated telephone line, with capacity to access 20 **OR** 100, **as directed**, telephones, and with electronic directory, **as directed**.
- f. Vehicle Loop Detector: System including automatic closing timer with adjustable time delay before closing, timer cutoff switch, **as directed**, and loop detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide electronic detector with adjustable detection patterns, adjustable sensitivity and frequency settings, and panel indicator light designed to detect presence or transit of a vehicle over an embedded loop of wire and to emit a signal activating the gate operator. Provide number of loops consisting of multiple strands of wire, number of turns, loop size, and method of placement at location shown on Drawings, as recommended in writing by detection system manufacturer for function indicated.
  - 1) Loop:
    - a) Wire, in size indicated for field assembly, for pave-over **OR** saw cut with epoxy-grouted, **as directed**, installation.  
**OR**  
Loop: Factory preformed in size indicated; style for pave-over **OR** saw cut with epoxy-grouted, **as directed**, installation.
- g. Vehicle Presence Detector: System including automatic closing timer with adjustable time delay before closing, timer cutoff switch, **as directed**, and presence detector designed to open and close gate **OR** hold gate open until traffic clears **OR** reverse gate, **as directed**. Provide retroreflective **OR** emitter/receiver, **as directed**, detector with adjustable detection zone pattern and sensitivity, designed to detect the presence or transit of a vehicle in gate pathway when infrared beam in zone pattern is interrupted, and to emit a signal activating the gate operator.
5. Obstruction Detection Devices: Provide each motorized gate with automatic safety sensor(s). Activation of sensor(s) causes operator to immediately function as follows:
  - a. Action:
    - 1) Reverse gate in both opening and closing cycles and hold until clear of obstruction.  
**OR**  
Stop gate in opening cycle and reverse gate in closing cycle and hold until clear of obstruction.
  - b. Internal Sensor: Built-in torque or current monitor senses gate is obstructed.
  - c. Sensor Edge: Contact-pressure-sensitive safety edge, profile, and sensitivity designed for type of gate and component indicated, in locations as follows. Connect to control circuit using take-up cable reel **OR** self-coiling cable **OR** gate edge transmitter and operator receiver system, **as directed**.
    - 1) Along entire gate leaf leading edge **OR** Along entire gate leaf trailing edge **OR** Across entire gate leaf bottom edge **OR** Along entire length of gate posts **OR** Along entire length of gate guide posts **OR** Where indicated on Drawings, **as directed**.
  - d. Photoelectric/Infrared Sensor System: Designed to detect an obstruction in gate's path when infrared beam in the zone pattern is interrupted.
6. Limit Switches: Adjustable switches, interlocked with motor controls and set to automatically stop gate at fully retracted and fully extended positions.
7. Emergency Release Mechanism: Quick-disconnect release of operator drive system of the following type of mechanism, permitting manual operation if operator fails. Design system so control-circuit power is disconnected during manual operation.
  - a. Type:



- 1) Integral fail-safe release, allowing gate to be pushed open without mechanical devices, keys, cranks, or special knowledge.  
**OR**  
Mechanical device, key, or crank-activated release.
8. Operating Features:
  - a. Digital Microprocessor Control: Electronic programmable means for setting, changing, and adjusting control features with capability for monitoring and auditing gate activity, **as directed**. Provide unit that is isolated from voltage spikes and surges.
  - b. System Integration: With controlling circuit board capable of accepting any type of input from external devices.
  - c. Master/Slave Capability: Control stations designed and wired for gate pair operation.
  - d. Automatic Closing Timer: With adjustable time delay before closing and timer cutoff switch, **as directed**.
  - e. Open Override Circuit: Designed to override closing commands.
  - f. Reversal Time Delay: Designed to protect gate system from shock load on reversal in both directions.
  - g. Maximum Run Timer: Designed to prevent damage to gate system by shutting down system if normal time to open gate is exceeded.
  - h. Clock Timer: 24-hour **OR** Seven-day, **as directed**, programmable for regular events.
9. Accessories:
  - a. Warning Module: Audio **OR** Visual, **as directed**, ADA/ABA-compliant, constant-light **OR** strobe-light, **as directed**, alarm sounding three to five seconds in advance of gate operation and continuing until gate stops moving.
  - b. Battery Backup System: Battery-powered drive and access-control system, independent of primary drive system:
    - 1) Fail Safe: Gate opens and remains open until power is restored.
    - 2) Fail Secure: Gate cycles on battery power, then fail safe when battery is discharged.
  - c. External electric-powered solenoid **OR** magnetic, **as directed**, lock with delay timer allowing time for lock to release before gate operates.
  - d. Fire **OR** Postal, **as directed**, box.
  - e. Fire strobe **OR** siren, **as directed**, alarm.
  - f. Intercom System: as directed by the Owner.
  - g. Instructional, Safety, and Warning Labels and Signs: According to UL 325 **OR** Manufacturer's standard for components and features specified **OR** As indicated on Drawings, **as directed**.
- N. Aluminum Finishes
  1. Baked-Enamel or Powder-Coat Finish: AAMA 2603 except with a minimum dry film thickness of **2 mils (0.05 mm)**. Comply with coating manufacturer's written instructions for cleaning, conversion coating, and applying and baking finish.
    - a. Color and Gloss: As selected from manufacturer's full range.
- O. Steel Finishes
  1. Surface Preparation: Clean surfaces according to SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning" **OR** SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning", **as directed**.
    - a. After cleaning, apply a conversion coating suited to the organic coating to be applied over it.
  2. Powder Coating: Immediately after cleaning, apply 2-coat finish consisting of epoxy primer and TGIC polyester topcoat, with a minimum total dry film thickness of not less than **8 mils (0.20 mm)**. Comply with coating manufacturer's written instructions.
    - a. Color and Gloss: As selected from manufacturer's full range.
  3. Primer Application: Apply zinc-rich epoxy primer immediately after cleaning, to provide a minimum dry film thickness of **2 mils (0.05 mm)** per applied coat, to surfaces that will be exposed after assembly and installation, and to concealed surfaces.

4. Shop-Painted Finish: Comply with Division 09 Section(s) "Exterior Painting" OR "High-performance Coatings", **as directed**.
5. High-Performance Coating: Apply epoxy intermediate and polyurethane topcoats to prime-coated surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.
  - a. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

P. Metallic-Coated Steel Finishes

1. Galvanized Finish: Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A 780.
2. Surface Preparation: Clean surfaces with nonpetroleum solvent so surfaces are free of oil and other contaminants. After cleaning, apply a zinc-phosphate, **as directed**, conversion coating suited to the organic coating to be applied over it. Clean welds, mechanical connections, and abraded areas and repair galvanizing to comply with ASTM A 780.
3. Powder Coating: Immediately after cleaning and pretreating, apply TGIC polyester powder-coat finish, with a minimum dry film thickness of **2 mils (0.05 mm)**.
  - a. Color and Gloss: As selected from manufacturer's full range.
4. Powder Coating: Immediately after cleaning and pretreating, apply 2-coat finish consisting of zinc-rich, **as directed**, epoxy prime coat and TGIC polyester topcoat, with a minimum dry film thickness of **2 mils (0.05 mm)** for topcoat. Comply with coating manufacturer's written instructions to achieve a minimum total dry film thickness of **4 mils (0.10 mm)**.
  - a. Color and Gloss: As selected from manufacturer's full range.
  - b. Comply with surface finish testing requirements in ASTM F 2408 except change corrosion-resistance requirement to 3000 hours without failure, **as directed**.
5. High-Performance Coating: Apply epoxy primer, epoxy intermediate coat, and polyurethane topcoat to prepared surfaces. Comply with coating manufacturer's written instructions and with requirements in SSPC-PA 1, "Paint Application Specification No. 1: Shop, Field, and Maintenance Painting of Steel," for shop painting. Apply at spreading rates recommended by coating manufacturer.
  - a. Match approved Samples for color, texture, and coverage. Remove and refinish, or recoat work that does not comply with specified requirements.

### 1.3 EXECUTION

A. Examination

1. Examine areas and conditions, with Installer present, for compliance with requirements for site clearing, earthwork, pavement work, construction layout, and other conditions affecting performance of the Work.
2. Do not begin installation before final grading is completed unless otherwise permitted by the Owner.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

B. Preparation

1. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of **500 feet (152.5 m)** or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

C. Decorative Fence Installation

1. Install fences according to manufacturer's written instructions.  
**OR**  
Install fences by setting posts as indicated and fastening rails and infill panels to posts. Peen threads of bolts after assembly to prevent removal, **as directed**.



2. Post Excavation: Drill or hand-excavate holes for posts in firm, undisturbed soil. Excavate holes to a diameter of not less than 4 times post size and a depth of not less than **24 inches (600 mm)** plus **3 inches (75 mm)** for each **foot (300 mm)** or fraction of **a foot (300 mm)** that fence height exceeds **4 feet (1200 mm)**.
3. Post Setting: Set posts in concrete **OR** with mechanical anchors **OR** by mechanically driving into soil, **as directed**, at indicated spacing into firm, undisturbed soil.
  - a. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
  - b. Concrete Fill: Place concrete around posts and sleeves, **as directed**, and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
    - 1) Exposed Concrete: Extend **2 inches (50 mm)** above grade. Finish and slope top surface to drain water away from post.
    - 2) Concealed Concrete: Top **2 inches (50 mm)** below grade as indicated on Drawings to allow covering with surface material. Slope top surface of concrete to drain water away from post.
  - c. Posts Set in Concrete: Extend post to within **6 inches (150 mm)** of specified excavation depth, but not closer than **3 inches (75 mm)** to bottom of concrete.
  - d. Posts Set into Concrete in Sleeves: Use galvanized-steel pipe sleeves with inside diameter at least **3/4 inch (20 mm)** larger than outside diagonal dimension of post, preset and anchored into concrete for installing posts.
    - 1) Extend posts at least **5 inches (125 mm)** into sleeve.
    - 2) After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions; shape and smooth to shed water. Finish and slope top surface of grout to drain water away from post.
  - e. Posts Set into Voids in Concrete: Form or core drill holes not less than **3/4 inch (20 mm)** larger than outside diagonal dimension of post.
    - 1) Extend posts at least **5 inches (125 mm)** into concrete.
    - 2) Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink grout, mixed and placed to comply with grout manufacturer's written instructions. Finish and slope top surface of grout to drain water away from post.
  - f. Mechanically Driven Posts: Drive into soil to depth of **30 inches (762 mm) OR 36 inches (914 mm)**, **as directed**. Protect post top to prevent distortion.
  - g. Space posts uniformly at **6 feet (1.83 m) OR 8 feet (2.44 m)**, **as directed**, o.c.
- D. Gate Installation
  1. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.
- E. Gate Operator Installation
  1. General: Install gate operators according to manufacturer's written instructions, aligned and true to fence line and grade.
  2. Excavation for Support Posts **OR** Pedestals **OR** Concrete Bases, **as directed**: Hand-excavate holes for bases, in firm, undisturbed soil to dimensions and depths and at locations as required by gate operator component manufacturer's written instructions and as indicated.
  3. Concrete Bases: Cast-in-place or precast concrete, depth not less than **12 inches (300 mm) OR 6 to 12 inches (150 to 300 mm)** below frost line, **as directed**, dimensioned and reinforced according to gate operator component manufacturer's written instructions and as indicated on Drawings.
  4. Vehicle Loop Detector System: Cut grooves in pavement, **as directed**, and bury and seal wire loop according to manufacturer's written instructions. Connect to equipment operated by detector.

5. Comply with NFPA 70 and manufacturer's written instructions for grounding of electric-powered motors, controls, and other devices.

F. Grounding And Bonding

1. Fence Grounding: Install at maximum intervals of 1500 feet (450 m) except as follows:
  - a. Fences within 100 Feet (30 m) of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 750 feet (225 m).
    - 1) Gates and Other Fence Openings: Ground fence on each side of opening.
      - a) Bond metal gates to gate posts.
      - b) Bond across openings, with and without gates, except openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches (460 mm) below finished grade.
2. Protection at Crossings of Overhead Electrical Power Lines: Ground fence at location of crossing and at a maximum distance of 150 feet (45 m) on each side of crossing.
3. Fences Enclosing Electrical Power Distribution Equipment: Ground as required by IEEE C2 unless otherwise indicated.
4. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches (150 mm) below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at the grounding location.
5. Bonding Method for Gates: Connect bonding jumper between gate post and gate frame.
6. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.
  - a. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
  - b. Make connections with clean, bare metal at points of contact.
  - c. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
  - d. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
  - e. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.
7. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

G. Field Quality Control

1. Grounding-Resistance Testing: Engage a qualified testing agency to perform tests and inspections.
  - a. Grounding-Resistance Tests: Subject completed grounding system to a megger test at each grounding location. Measure grounding resistance not less than two full days after last trace of precipitation, without soil having been moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural grounding resistance. Perform tests by two-point method according to IEEE 81.
  - b. Excessive Grounding Resistance: If resistance to grounding exceeds specified value, notify the Owner promptly. Include recommendations for reducing grounding resistance and a proposal to accomplish recommended work.
  - c. Report: Prepare test reports certified by a testing agency of grounding resistance at each test location. Include observations of weather and other phenomena that may affect test results.

H. Adjusting

1. Gates: Adjust gates to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire



operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

2. Automatic Gate Operators: Energize circuits to electrical equipment and devices. Adjust operators, controls, safety devices, alarms, **as directed**, and limit switches.
    - a. Hydraulic Operators: Purge Operating System, Adjust Pressure And Fluid Levels, And Check For Leaks.
    - b. Operational Test: After Electrical Circuitry Has Been Energized, Start Units To Confirm Proper Motor Rotation And Unit Operation.
    - c. Test And Adjust Controls, Alarms, **as directed**, And Safeties. Replace Damaged And Malfunctioning Controls And Equipment.
  3. Lubricate hardware, gate operators, **as directed**, and other moving parts.
- I. Demonstration
1. Train Owner's personnel to adjust, operate, and maintain gates.

END OF SECTION 32 31 19 00



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Task	Specification	Specification Description
32 31 19 00	01 22 16 00	No Specification Required
32 31 19 00	32 31 13 13	High-Security Chain-Link Fences And Gates
32 31 23 00	01 22 16 00	No Specification Required

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## SECTION 32 31 29 00 - PERMANENT WOOD FENCING

### 1.1 GENERAL

#### A. Description Of Work

1. The specification covers the furnishing and installation of materials for repair and maintenance of permanent wood fencing. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

- B. Submittals: Shop drawings shall be submitted for approval.

### 1.2 PRODUCTS

#### A. Review MSDS and Manufacturers Application Instructions.

#### B. Pickets:

1. Size: Wood For picket shall match the existing fencing in material, configuration, dimensions, texture, and finishes,
2. Attachment: Hot-dipped galvanized nails complying with Fed. Spec. FF-N-105 shall be used to fasten pickets to rails.

#### C. Framework:

1. Line Posts: 4 x 4 of required length to match existing post height and extend into the ground as required to ensure rigid installation.
2. Terminal and Corner Posts: 4 x 4 of required length.
3. Gate Posts: 4 x 6 and of the length required for firm embedment to resist gate action.
4. Top Rail: 2 x 4 of length required to span between posts.
5. Where bracing is required, it shall match top and bottom rails in dimension and finish.
6. Metal Posts and Rails: Solid mild steel galvanized in compliance with ASTM A 123 of the length and style required to match existing.

#### D. Gates:

1. Frame: 2 x 4 members with attached pickets. Configuration of gate shall match that of existing gates.
2. Bracing: Single 2 x 4 running diagonally across the gate to opposite corners of the frame.
3. Hardware: Hinges, latches, and other hardware shall be hot dipped galvanized and of configurations to match existing hardware. Bolts and nuts shall comply with ASTM A 307 and galvanized in compliance with ASTM A 153.

- E. Finish: All wood fence members shall be given a pressure preservative treatment in a closed retort. The treatment shall comply with Fed. Spec. TT-W-571. Wood cut or sawed after treatment shall have the cut surfaces well brush-coated with the preservative used in the treatment. Paint to match existing after treatment and installation.

### 1.3 EXECUTION

- A. Posts: Hold in line in a true vertical position by temporary bracing until backfilling is completed. Compact by hand tamping or other suitable methods to a density comparable to that of adjacent ground. Posts of fencing that are higher than four feet and exposed to strong winds and posts at all gates shall be of heavy construction and shall be embedded in concrete.





- B. Rails: Install at the height and in the manner required to match existing fencing, and secure to post with fasteners similar to existing.
- C. Pickets: Space, attach, and position to match existing pattern and attachment methods.
- D. Accessories: Install to match existing conditions.

END OF SECTION 32 31 29 00

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Task	Specification	Specification Description
32 31 29 00	01 22 16 00	No Specification Required

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## SECTION 32 32 13 00 - SEGMENTAL RETAINING WALLS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for segmental retaining walls. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes single- and multiple- depth segmental retaining walls with and without soil reinforcement.

#### C. Performance Requirements

1. Basis of Design: Design of segmental retaining walls is based on products indicated. If comparable products of other manufacturers are proposed, provide engineering design for proposed products, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Delegated Design: Design segmental retaining walls, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
3. Structural Performance: Engineering design shall be based on the following loads and be according to NCMA's "Design Manual for Segmental Retaining Walls."
4. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
  - a. Superimposed loads (surcharge) indicated on Drawings.
5. Seismic Performance: Engineering design shall be based on the following loads and factors and be according to NCMA's "Segmental Retaining Walls - Seismic Design Manual."
  - a. Gravity loads due to soil pressures resulting from grades and sloped backfill indicated.
  - b. Superimposed loads (surcharge) indicated on Drawings.
  - c. Horizontal Peak Ground Acceleration (A) for Project: **As directed.**

#### D. Preconstruction Testing

1. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:
  - a. Test soil reinforcement and backfill materials for pullout resistance according to ASTM D 6706.
  - b. Test soil reinforcement and backfill materials for coefficient of friction according to ASTM D 5321.

#### E. Submittals

1. Product Data: For each type of product indicated.
2. Samples: For each color and texture of concrete unit required. Submit full-size units **OR** sections of units not less than **3 inches (75 mm)** square, **as directed.**
  - a. Include one full-size unit for each type of concrete unit required.
3. Delegated-Design Submittal: For segmental retaining walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
  - a. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.
4. Product Certificates: For segmental retaining wall units and soil reinforcement, from manufacturer.

- a. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.
- b. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.
5. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for segmental retaining wall units and soil reinforcement.
  - a. Include test data for freeze-thaw durability of segmental retaining wall units.
  - b. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.
  - c. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.

F. Quality Assurance

1. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
2. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects.
  - a. Build mockup of segmental retaining wall as shown on Drawings **OR** approximately **72 inches (1800 mm)** long by not less than **36 inches (900 mm)** high above finished grade at front of wall, **as directed**.
    - 1) Include typical soil reinforcement.
    - 2) Include typical base and cap or finished top construction.
    - 3) Include backfill to typical finished grades at both sides of wall.
    - 4) Include typical end construction at one end of mockup.
    - 5) Include **36-inch (900-mm)** return at 1 end of mockup, with typical corner construction.
  - b. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.
3. Preinstallation Conference: Conduct conference at Project site.
  - a. Review methods and procedures related to segmental retaining walls including, but not limited to, the following:
    - 1) Structural load limitations.
    - 2) Construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
    - 3) Field quality-control procedures.

G. Delivery, Storage, And Handling

1. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.
2. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above **160 deg F (71 deg C)** or below **32 deg F (0 deg C)**, and other conditions that might damage them. Verify identification of geosynthetics before using and examine them for defects as material is placed.

## 1.2 PRODUCTS

A. Segmental Retaining Wall Units

1. Concrete Units: ASTM C 1372, Normal Weight, except that maximum water absorption shall not exceed 7 percent by weight and units shall not differ in height more than plus or minus **1/16 inch (1.6 mm)** from specified dimension.
  - a. Provide units that comply with requirements for freeze-thaw durability.
  - b. Provide units that interlock with courses above and below by means of integral lugs or lips, pins, clips, or hollow cores filled with drainage fill.
2. Color: As selected from manufacturer's full range.

3. Shape and Texture: Provide units of basic shape and dimensions indicated with machine-split textured **OR** smooth, **as directed**, exposed faces.
4. Shape and Texture: Provide units matching basic shape, dimensions, and face texture indicated by referencing manufacturer's pattern designation.
5. Shape and Texture: Provide units of any basic shape and dimensions that will produce segmental retaining walls of dimensions and profiles indicated without interfering with other elements of the Work and with machine-split textured, flat exposed face **OR** shaped exposed face with deeply beveled vertical edges, **as directed**.
6. Batter: Provide units that offset from course below to provide at least 1:24 **OR** 1:16 **OR** 1:14 **OR** 1:8 **OR** 1:5, **as directed**, batter.
7. Cap Units: Provide cap units of shape indicated **OR** same shape as other units, **as directed**, with smooth, as-cast top surfaces without holes or lugs.
8. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces matching face **OR** as indicated, **as directed**.

B. Installation Materials

1. Pins: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.
2. Clips: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.
3. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.
4. Leveling Base: Comply with requirements in Division 31 Section "Earth Moving" for base material **OR** Division 33 Section "Subdrainage" for drainage fill, **as directed**.
  - a. Leveling Course: Lean concrete with a compressive strength of not more than 500 psi (3.4 MPa).
5. Drainage Fill: Comply with requirements in Division 33 Section "Subdrainage".
6. Reinforced-Soil Fill: ASTM D 2487; GW, GP, SW, SP, and SM soil classification groups or a combination of these groups; free of debris, waste, frozen materials, vegetation, and other deleterious matter; meeting the following gradation according to ASTM C 136: 20 to 100 percent passing No. 4 (4.75-mm) sieve, 0 to 60 percent passing No. 40 (0.425-mm) sieve, 0 to 35 percent passing No. 200 (0.075-mm) sieve, and with fine fraction having a plasticity index of less than 20.
7. Nonreinforced-Soil Fill: Comply with requirements in Division 31 Section "Earth Moving" for satisfactory soils.
8. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent.
  - a. Apparent Opening Size: No. 70 to 100 (0.212- to 0.150-mm) sieve, maximum; ASTM D 4751.
  - b. Minimum Grab Tensile Strength: 110 lb (49.9 kg); ASTM D 4632.
  - c. Minimum Weight: 4 oz./sq. yd. (132 g/sq. m).
9. Subdrainage Pipe and Filter Fabric: Comply with requirements in Division 33 Section "Subdrainage".
  - a. Product Type: Knitted or woven geogrid made from polyester yarns with a protective coating **OR** Molded geogrid made from high-density polyethylene **OR** Woven geotextile made from polyamides, polyesters, or polyolefins, **as directed**.

C. Source Quality Control

1. Direct manufacturer to test and inspect each roll of soil reinforcement at the factory for minimum average roll values for geosynthetic index property tests, including the following:
  - a. Weight.
  - b. Roll size.
  - c. Grab or single-rib strength.
  - d. Aperture opening.
  - e. Rib or yarn size.

### 1.3 EXECUTION

#### A. Examination

1. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of segmental retaining walls.
2. Proceed with installation only after unsatisfactory conditions have been corrected.

#### B. Retaining Wall Installation

1. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
  - a. Lay units in running bond **OR** bond pattern indicated, **as directed**.
  - b. Form corners and ends by using special units **OR** cutting units with motor-driven saw **OR** splitting units with mason's hammer and chisel, **as directed**.
2. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight according to ASTM D 698.
  - a. Leveling Course: At Contractor's option, unreinforced lean concrete may be substituted for upper **1 to 2 inches (25 to 50 mm)** of base **OR** Place unreinforced lean concrete over leveling base **1 to 2 inches (25 to 50 mm)** thick, **as directed**. Compact and screed concrete to a smooth, level surface.
3. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.
  - a. Tamp units into leveling base as necessary to bring tops of units into a level plane.
4. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.
  - a. For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.
  - b. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.
  - c. For units with lips at bottom rear of units, slide units as far forward as possible for firm contact of lips with units below.
  - d. For units with pins, install pins and align units.
  - e. For units with clips, install clips and align units.
5. Cap Units: Place cap units and secure with cap adhesive.

#### C. Fill Placement

1. General: Comply with requirements in Division 31 Section "Earth Moving", NCMA's "Segmental Retaining Wall Installation Guide," and segmental retaining wall unit manufacturer's written instructions.
2. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.
3. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall and place and spread fills toward embankment.
  - a. Use only hand-operated compaction equipment within **48 inches (1200 mm)** of wall, or one-half of height above bottom of wall, whichever is greater.
  - b. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight according to ASTM D 698.
    - 1) In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight according to ASTM D 698.
    - 2) In areas where fill height exceeds **15 feet (4.5 m)**, compact reinforced-soil fill that will be more than **15 feet (4.5 m)** below finished grade to not less than 98 percent maximum dry unit weight according to ASTM D 698.

- 3) In areas where fill height exceeds **30 feet (9 m)**, compact reinforced-soil fill that will be more than **30 feet (9 m)** below finished grade to not less than 100 percent maximum dry unit weight according to ASTM D 698.
  - c. Compact nonreinforced-soil fill to comply with Division 31 Section "Earth Moving".
4. Place drainage geotextile against back of wall and place layer of drainage fill at least **12 inches (300 mm) OR 6 inches (150 mm)**, as directed, wide behind drainage geotextile to within **12 inches (300 mm)** of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.
5. Place a layer of drainage fill at least **12 inches (300 mm) OR 6 inches (150 mm)**, as directed, wide behind wall to within **12 inches (300 mm)** of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.
6. Wrap subdrainage pipe with filter fabric and place in drainage fill as indicated, sloped not less than 0.5 percent to drain.
7. Place impervious fill over top edge of drainage fill layer.
8. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at base of wall away from wall. Provide uniform slopes that will prevent ponding.
9. Place soil reinforcement in horizontal joints of retaining wall where indicated and according to soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of **8 inches (200 mm)** into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.
  - a. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
  - b. Place geosynthetics with seams, if any, oriented perpendicular to segmental retaining walls.
  - c. Do not dump fill material directly from trucks onto geosynthetics.
  - d. Place at least **6 inches (150 mm)** of fill over reinforcement before compacting with tracked vehicles or **4 inches (100 mm)** before compacting with rubber-tired vehicles.
  - e. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.
- D. Construction Tolerances
  1. Variation from Level: For bed joint lines along walls, do not exceed **1-1/4 inches in 10 feet (32 mm in 3 m)**, **3 inches (75 mm)** maximum.
  2. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than **1-1/4 inches in 10 feet (32 mm in 3 m)**.
  3. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than **1-1/4 inches in 10 feet (32 mm in 3 m)**.
- E. Field Quality Control
  1. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
  2. Comply with requirements in Division 31 Section "Earth Moving" for field quality control.
    - a. In each compacted backfill layer, perform at least 1 field in-place compaction test for each **150 feet (45 m)** or less of segmental retaining wall length.
    - b. In each compacted backfill layer, perform at least 1 field in-place compaction test for each **24 inches (600 mm)** of fill depth and each **50 feet (15 m)** or less of segmental retaining wall length.
- F. Adjusting
  1. Remove and replace segmental retaining wall construction of the following descriptions:
    - a. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if the Owner approves methods and results.
    - b. Segmental retaining walls that do not match approved Samples.
    - c. Segmental retaining walls that do not comply with other requirements indicated.
  2. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.



END OF SECTION 32 32 13 00

NOT FOR BID



Task	Specification	Specification Description
32 32 16 00	03 41 23 00	Plant-Precast Structural Concrete
32 32 23 13	32 32 13 00	Segmental Retaining Walls
32 32 26 00	32 32 13 00	Segmental Retaining Walls
32 32 29 00	32 32 13 00	Segmental Retaining Walls
32 32 53 00	32 32 13 00	Segmental Retaining Walls

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## SECTION 32 33 13 00 - MISCELLANEOUS SITE AND STREET FURNISHINGS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of miscellaneous site and street furnishings. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Shop Drawings: Fabrication and installation drawings for each type of product indicated.
2. Product Data: For each type of product indicated.

#### C. Qualification Of Welders

1. Qualify welders in accordance with AWS D1.1 using procedures, materials, and equipment of the type required for the work.

#### D. Delivery, Storage, And Protection

1. Protect from corrosion, staining, and other types of damage. Store items in an enclosed area free from contact with soil and weather. Remove and replace damaged items with new items.

### 1.2 PRODUCTS

#### A. Precast Benches

1. Design precast benches in accordance with manufacturer's standards, size as indicated. Finish and color as indicated selected from manufacturer's standards.
2. Glass Fiber Reinforced Concrete (GFRC) Benches
  - a. Provide glass fiber reinforced concrete (GFRC) benches at locations as directed. Comply with PCI MNL-128 recommended practice for glass fiber reinforced concrete, including Appendix G, Polymer Modified Glass Fiber Reinforced Concrete Panels.
  - b. Design precast benches to sustain a live load of not less than **200 pounds per square foot (10 kPa)**, constructed of minimum 3000 psi concrete with ASTM C 150 cement, white or grey color consistent with final finish, using alkali resistant (AR) glass fibers produced specifically for use in glass fiber reinforced concrete, minimum three percent glass fiber content. Aggregate shall be clear silica sand aggregate; washed, dried and free from deleterious materials. Provide type with successful history of uses in GFRC fabrication standard with the manufacturer. Provide manufacturer's standard acrylic thermoplastic copolymer admixture.
  - c. Provide factory finished units standard with the manufacturer; texture and color as selected.
3. Precast Concrete/Cast Stone Benches
  - a. Provide reinforced precast concrete benches consisting of a mixture of cement, aggregates and mineral colors suitable for exterior use, located as directed.
  - b. Design benches to sustain a live load of not less than **200 pounds per square foot (10 kPa)**.
    - 1) Portland cement: ASTM C150 Type I, II, or III.
    - 2) Aggregate: ASTM C33, maximum size **3/4 inch (19 mm)**.
    - 3) Reinforcing steel: ASTM A615/A615M
    - 4) Galvanized wire mesh: ASTM A1064
    - 5) Integral color: ASTM C979, pure mineral oxide, limeproof and non-fading.
    - 6) Provide minimum **5000 psi (35 MPa)** 28 day compressive strength concrete, maximum five percent absorption.

7) Admixture: ASTM C260 for air-entraining.

B. Precast Concrete Bicycle Rack

1. Provide one-piece precast concrete bicycle rack base with embedded galvanized metal hitching loops. Design bicycle rack with wheel notches for bike support and wheel locking device.

C. Precast Concrete Bollards

1. Provide reinforced concrete bollards **12 inch (300 mm) OR 18 inch (450 mm), as directed**, square **OR** round, **as directed**, height as indicated, suitable for ground mount installation. Provide exposed aggregate or sandblast finish as indicated; manufacturer's standard clear acrylic sealer.
  - a. Portland cement: ASTM C150, Type I II or III.
  - b. Aggregate: ASTM C33, maximum size **3/4 inch (19 mm)**.
  - c. Reinforcing steel: ASTM A615/A615M.
  - d. Integral color: ASTM C979, pure mineral oxide, limeproof and non-fading.
  - e. Concrete strength: **5000 psi (35 MPa)**, 28 day minimum compressive strength.
  - f. Admixture: ASTM C260 for air-entraining.

D. Planters, Receptacles, Ash Receptacles

1. Provide for waste receptacles spun aluminum **OR** reinforced fiberglass, **as directed**, flat **OR** domed, **as directed**, tops and removable semi-rigid plastic liner insert. Provide top-mounted ash trays for ash receptacles.
2. Glass Fiber Reinforced Concrete (GFRC) Precast:
  - a. Provide glass fiber reinforced concrete (GFRC) precast planters/waste receptacles/ash receptacles at locations as directed. Comply with PCI MNL-117 and PCI MNL-128.
  - b. Materials: Provide manufacturer's standard shell thickness of **3/8 to 5/8 inch (9 to 16 mm)**.
    - 1) Cement: ASTM C150, use only one brand and type of cement throughout the Project.
    - 2) Glass Fibers: Alkali resistant (AR) glass fibers produced specifically for use in glass fiber reinforced concrete. Glass content of GFRC unit to be a minimum of three percent.
    - 3) Aggregates: clear silica sand; washed, dried, and free from deleterious materials; provide type with successful history of use in GFRC and as standard with the manufacturer.
    - 4) Compressive Strength: Minimum **3000 psi (20/25 MPa)** 28 day strength.
    - 5) Density: Approximately **120 pcf (1921 kg/cu. m)**.
    - 6) Polymer Admixture: Manufacturer's standard acrylic thermoplastic copolymer.
  - c. Finishes: Provide factory finished units with manufacturer's standard texture or sandblasted finish as selected.
    - 1) Cement: White or grey as consistent with final finish.
3. Precast Concrete/Cast Stone Planters
  - a. Provide reinforced precast concrete planters/waste receptacles/ash receptacles consisting of a mixture of cement, aggregates, and mineral colors suitable for exterior use as located on the drawings. Provide manufacturer's standard exposed aggregate or sandblast finish (with clear acrylic coating) as selected.
    - 1) Portland Cement: ASTM C150, gray, Type I.
    - 2) Aggregate: ASTM C33, crushed limestone and sand.
    - 3) Galvanized Steel Mesh: ASTM A1064.
    - 4) Integral Color: ASTM C979, pure mineral oxide, limeproof and non-fading.
    - 5) Concrete Strength: **4000 psi (30 MPa)** minimum compressive strength at 28 days.
    - 6) Admixture: ASTM C260 for air-entraining.
4. Wood Planters
  - a. Provide manufacturer's standard wood planter/waste receptacle/ash receptacles fabricated of **3/4 inch (19 mm)** thick tongue and grooved wood slats permanently bonded with

fiberglass interior shell. Provide wood top trim for square planters and fiberglass top trim for round planters.

- 1) Wood Species: As directed.
- 2) Fiberglass: Molded with multiple laminations of glass fiber impregnated with polyester isophthalic thermosetting resins with a finish of 12-15 mil (0.30-0.38 mm) color impregnated polyester gel coat.
- 3) Metal Frame: Black color-coated steel frame.
5. Wood Planters with Metal Frames
  - a. Provide manufacturer's standard wood planter/waste receptacle/ash receptacle with galvanized steel welded frames, and nominal 2 inch (50 mm) tongue and grooved, beveled or square cut wood staves. Attach wood staves to metal frame from inside with steel plated screws.
    - 1) Wood species: Kiln dried, maximum 19 percent moisture content, species as directed.
    - 2) Metal frame: Reinforced with steel bars as per manufacture's standard construction, black color factory finish coated.
    - 3) Bottom: 1/4 inch (6.25 mm) exterior grade redwood with drain holes.
    - 4) Liners: Removable galvanized steel or manufacturer's standard.
    - 5) Tops: Hinged top opening, spun aluminum open top with molded rim, ash top.
6. Fiberglass Planters/Waste Receptacles/Ash Receptacles
  - a. Provide reinforced fiberglass planters/waste receptacles/ash receptacles molded with multiple laminations of glass fiber impregnated with polyester isophthalic thermosetting resins; with 12-15 mil (0.30-0.38 mm) color impregnated polyester gel coat finish; minimum thickness of 1/4 inch (6.25 mm); color as selected.
  - b. Receptacles:
    - 1) Shall be manufactured by Maglin,
    - 2) Color: Malaga Green

#### E. Shelters

1. AISC S342L; AISC S335. Provide prefabricated shelter systems to meet design conditions indicated. Shelter design shall conform to all applicable State and Local Building Codes and shall meet manufacturer's standards of construction and materials. Shelter systems shall be preglazed, pre-drilled and pre-cut, shipped with all hardware and accessories necessary for complete field assembly.
2. Framing Systems: Framing system; columns, rafters, ridge, purlins and other structural framing members shall be aluminum/steel/wood as indicated. Manufacturer shall provide shop drawings and calculations prepared by a structural engineer.
  - a. Extruded aluminum alloy tubing shall conform to ASTM B429 6063-T5 or 3003-H14, anodized or powder coat finish, color as directed. Framing sizes and configurations shall be as required for size of structure indicated meeting manufacturer's standards and applicable building codes.
  - b. Structural steel shall conform to ASTM A36/A36M or ASTM A500, 36,000 psi (248 MPa) yield strength and 58,000 psi (400 MPa) tensile strength, factory finished with rust inhibited primer and powder coat conforming to ASTM D3451. Framing sizes and configurations shall be as required for size of structure indicated meeting manufacturer's standard and applicable building codes.
  - c. Wood framing system shall consist of surfaced four sides (S4S), #2 grade southern yellow pine solid timber columns with eased edges, pressure treated CCA (Copper Chrome Arsinat) 0.6 PCF (9.6 kg/cu.m) against decay, fungi and insect infestation, surfaced four sides (S4S), #1 grade, southern pine, glue-laminated columns manufactured in accordance with ANSI/AITC A190.1 and AITC certified glue-laminated structural grade southern yellow pine beams, rafters and purlins, factory sealed and individually wrapped for protection during shipment. Factory stain all wood members prior to shipment.
3. Roof Panels/Decking: Provide manufacturer's standard molded acrylic translucent roof panel, OR standing seam metal roof panel, OR wood decking, OR V-beam aluminum roof panels, OR



FRP roof panels, as indicated. Materials shall be factory finished and shipped with all necessary fasteners and accessories as required for complete site assembly.

4. Glazing: Factory installed in separate structural window frames, gasketed and glazed as per manufacturer's standard, interchangeable, glazing system. Provide **1/4 inch (6.25 mm)** acrylic sheet, OR tempered glass, OR polycarbonate plastic sheet OR mar-resistant polycarbonate plastic sheet, clear OR color.

#### F. Tables

1. Precast Concrete Tables: Provide reinforced precast concrete tables with smooth tops; minimum **4500 psi (35 MPa)** concrete, 28 day minimum compressive strength, consisting of a mixture of cement, aggregates, and mineral colors suitable for exterior use as located on the drawings. Provide manufacturer's standard exposed aggregate or sandblast finish with clear acrylic coating.
  - a. Portland cement: ASTM C150, gray, Type I.
  - b. Aggregate: ASTM C33, washed limestone and sand.
  - c. Galvanized wire mesh: **14 gage (1.9 mm), 2 by two inch (50 by 50 mm)**.
  - d. Welded wire fabric: ASTM A1064.
  - e. Reinforcing steel: ASTM A615/A615M.
  - f. Integral color: ASTM C979, pure mineral oxide, limeproof and non-fading.
  - g. Admixture: ASTM C260 for air-entraining..
2. Fiberglass Tables: Provide reinforced fiberglass table tops molded with multiple laminations of glass fiber impregnated with polyester isophthalic thermosetting resins, minimum thickness of **1/4 inch (6.25 mm)** with **12-15 mil (0.30-0.38 mm)** thickness color impregnated polyester gel coat, color as selected.
  - a. Steel pedestal base: ASTM A53 Schedule 40 steel pipe.
  - b. Mounting: Type as indicated.
  - c. Metal finish: Powder coating conforming to ASTM D3451 testing.
3. Perforated Steel Tables: Provide **14 gage (1.9 mm) OR 16 gage (1.6 mm), as directed**, perforated steel sheet table tops with solid metal edges as per manufacturer's standard. Weld tops to base as required for frame support.
  - a. Steel pedestal base: ASTM A53 Schedule 40 steel pipe, **2 3/8 inch (60 mm) O.D.**
  - b. Mounting: Type as indicated.
  - c. Hardware: Zinc or cadmium plated nuts, bolts, screws, and lock washers.
  - d. Metal finish: Powder coating conforming to ASTM D3451 testing.
4. Wood Seats and Tables
  - a. Provide manufacturer's standard wood seats and tables, minimum **1-5/8 inches (40 mm )** thick with rounded edges, with wood or metal bases as indicated. Provide fasteners and accessories required for on site assembly. Kiln dry and pressure treat wood components to manufacturer's standard, maximum 19 percent moisture content. Pre-treat metal components and provide manufacturer's standard primer and powder coat finish complying with ASTM D3451, color as selected.
    - 1) Design wood tables to sustain a live load of not less than **200 pounds per square foot (10 kPa)**.
    - 2) Provide kiln dried, surfaced four sides (S4S), clear all sides wood slats of species and sizes indicated.
      - a) Species: As directed.
      - b) Nominal wood slat sizes: As directed.
  - b. Support Base: Provide wood or metal support bases as per manufacturer's standard.
    - 1) Wood: Match in species, grade, grain, color and finish of the wood slats.
    - 2) Steel: ASTM A653/A653M.
    - 3) Cast grey iron: ASTM A 48/A48M, Class 30 or recycled cast grey iron ASTM A48/A48M, Class 25.
    - 4) Cast aluminum: ASTM B26/B26M or ASTM B108 as applicable.
    - 5) Design bases to support the loads imposed in the design of the tables.

#### G. Grates

1. Provide cast aluminum **OR** cast iron **OR** cast bronze **OR** punched steel **OR** stainless steel, **as directed**, tree grates in round **OR** square, **as directed**, model of sizes indicated on the drawings. Furnish complete with angle steel frames with finish to match tree grates.

H. Fabrication Finishes

1. Galvanizing: Hot-dip galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing: ASTM A123/A123M, ASTM A153/A153M or ASTM A653/A653M, as applicable.
2. Galvanize: Anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.
3. Repair of Zinc-Coated Surfaces: Repair damaged surfaces with galvanizing repair method and paint conforming to ASTM A780 or by the application of stick or thick paste material specifically designed for repair of galvanizing, as approved. Clean areas to be repaired and remove the slag from the welds. Heat surfaces to which stick or paste material is applied, with a torch to a temperature sufficient to melt the metallics in stick or paste; spread the molten material uniformly over surfaces to be coated and wipe the excess material off.
4. Pretreatment, Priming and Painting: Apply pretreatment, primer, and paint in accordance with manufacturer's printed instructions. On surfaces concealed in the finished construction or not accessible for finish painting, apply an additional prime coat to a minimum dry film thickness of **1.0 mil (0.03 mm)**. Tint additional prime coat with a small amount of tinting pigment.
5. Nonferrous Metal Surfaces: Protect by plating, anodic, or organic coatings.
6. Aluminum Surfaces
  - a. Surface Condition: Before finishes are applied, remove roll marks, scratches, rolled-in scratches, kinks, stains, pits, orange peel, die marks, structural streaks, and other defects which will affect uniform appearance of finished surfaces.

1.3 EXECUTION

A. Installation

1. Install items at locations indicated, according to manufacturer's instructions. Items listed below require additional procedures.
  - a. Assembly and Erection of Components: Items shall be shipped knocked-down (KD) ready for site assembly. Packaged components shall be complete including all accessories and hardware. Follow manufacturer's instructions for assembly and erection. Provide mounting bolts or hardware for mounting items to substrate.

B. Anchorage, Fastenings, And Connections

1. Provide anchorage where necessary for fastening furniture or furnishings securely in place. Include for anchorage not otherwise specified or indicated slotted inserts, expansion shields, and powder-driven fasteners, when approved for concrete; toggle bolts and through bolts for masonry; machine and carriage bolts for steel; through bolts, lag bolts, and screws for wood. Do not use wood plugs in any material. Provide non-ferrous attachments for non-ferrous metal. Make exposed fastenings of compatible materials, generally matching in color and finish, to which fastenings are applied. Conceal fastenings where practicable.

C. Built-In-Work

1. Form for anchorage metal work built-in with concrete or masonry, or provide with suitable anchoring devices as indicated or as required. Furnish metal work in ample time for securing in place as the work progresses.

D. Welding

1. Perform welding, welding inspection, and corrective welding, in accordance with AWS D1.1. Use continuous welds on all exposed connections. Grind visible welds smooth in the finished installation.



## E. Finishes: Dissimilar Materials

1. Where dissimilar metals are in contact, protect surfaces with a coat conforming to FS TT-P-664 to prevent galvanic or corrosive action. Where aluminum is in contact with concrete, mortar, masonry, wood, or absorptive materials subject to wetting, protect with ASTM D1187, asphalt-base emulsion.

## F. Bollards

1. Install in pipe sleeves embedded in concrete and filled with non-shrink grout or quick setting anchoring cement.

## G. Shelters

1. Secure to the adjacent construction with the clip angles attached to the concrete. Secure to concrete with not less than two **1/2 inch (12 mm)** diameter expansion bolts.
  - a. Glazing: Factory install windows into separate structural frame. Miter corners and connect internally by extruded aluminum corner keys or screw bosses with tamper-proof stainless steel screws. Provide continuous gasketing around windows set to metal frames. Provide **1/2 to 3/4 inch (13 to 19 mm)** deep pocket for polycarbonate glazing. Fully gasket and frame in independent interchangeable factory assembled units. Affix to shelter frame with **3/16 inch (5 mm)** shallow head aluminum rivets at approximately **13 1/4 inches (331 mm)** on centers for full **360 degrees (6.28 rad)**, rivet from inside of shelter.
  - b. Roof: Provide manufacturer's standard roof system including fascia **OR** gutter, **as directed**, assembly, ensuring a weather-tight seal and installation.

END OF SECTION 32 33 13 00



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Task	Specification	Specification Description
32 33 13 00	01 22 16 00	No Specification Required

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## SECTION 32 33 23 00 - SITE FURNISHINGS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for site furnishings. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Seating.
  - b. Tables.
  - c. Bicycle racks.
  - d. Bicycle lockers.
  - e. Trash receptacles.
  - f. Ash receptacles.
  - g. Planters.
  - h. Bollards.

#### C. Submittals

1. Product Data: For each type of product indicated.
2. Samples: For each type of exposed finish required.
3. Product Schedule: For site furnishings. Use same designations indicated on Drawings.
4. Material Certificates: For site furnishings, signed by manufacturers.
  - a. Wood Preservative Treatment: Include certification by treating plant stating type of preservative solution and pressure process used, net amount of preservative retained, and compliance with applicable standards.
  - b. Sustainably Harvested Wood: Include certification by manufacturer and from sources that participate in sustained yield programs.
  - c. Recycled plastic.
5. Maintenance Data: For site furnishings to include in maintenance manuals.

### 1.2 PRODUCTS

#### A. Materials

1. Aluminum: Alloy and temper recommended by aluminum producer and finisher for type of use and finish indicated; free of surface blemishes and complying with the following:
  - a. Rolled or Cold-Finished Bars, Rods, and Wire: **ASTM B 211 (ASTM B 211M)**.
  - b. Extruded Bars, Rods, Wire, Profiles, and Tubes: **ASTM B 221 (ASTM B 221M)**.
  - c. Structural Pipe and Tube: ASTM B 429.
  - d. Sheet and Plate: **ASTM B 209 (ASTM B 209M)**.
  - e. Castings: ASTM B 26/B 26M.
2. Steel and Iron: Free of surface blemishes and complying with the following:
  - a. Plates, Shapes, and Bars: ASTM A 36/A 36M.
  - b. Steel Pipe: Standard-weight steel pipe complying with ASTM A 53, or electric-resistance-welded pipe complying with ASTM A 135.
  - c. Tubing: Cold-formed steel tubing complying with ASTM A 500.
  - d. Mechanical Tubing: Cold-rolled, electric-resistance-welded carbon or alloy steel tubing complying with ASTM A 513, or steel tubing fabricated from steel complying with ASTM A 1011/A 1011M and complying with dimensional tolerances in ASTM A 500; zinc coated internally and externally.

- e. Sheet: Commercial steel sheet complying with ASTM A 1011/A 1011M.
- f. Perforated Metal: From steel sheet not less than **0.0747-inch (1.9-mm)** **OR** **0.0897-inch (2.3-mm)** **OR** **0.1196-inch (3.0-mm)**, **as directed**, nominal thickness; manufacturer's standard perforation pattern.
- g. Expanded Metal: Carbon-steel sheets, deburred after expansion, and complying with ASTM F 1267.
- h. Malleable-Iron Castings: ASTM A 47/A 47M, grade as recommended by fabricator for type of use intended.
- i. Gray-Iron Castings: ASTM A 48/A 48M, Class 200.
- 3. Stainless Steel: Free of surface blemishes and complying with the following:
  - a. Sheet, Strip, Plate, and Flat Bars: ASTM A 666.
  - b. Pipe: Schedule 40 steel pipe complying with ASTM A 312/A 312M.
  - c. Tubing: ASTM A 554.
- 4. Wood: Surfaced smooth on four sides with eased edges; kiln dried, free of knots, solid stock of species indicated.
  - a. Wood Species: Manufacturer's standard.
    - 1) Douglas Fir: Clear Grade, vertical grain.
    - 2) Pine: Southern pine; No. 2 or better; preservative treated, kiln dried after treatment.
    - 3) Eastern White **OR** Red **OR** Yellow **OR** Cedar, **as directed**: Select Grade or better.
    - 4) Redwood: Clear all heart **OR** Construction heart or better, **as directed**, free-of-heart center.
    - 5) Teak (Tectona Grandis): Clear Grade. Provide wood obtained from sources that participate in a well-managed forest and chain-of-custody program certified by an independent agency accredited by FSC.
    - 6) Finish: Manufacturer's standard stain and transparent sealer **OR** transparent wood preservative treatment and sealer, **as directed**.
- 5. Fiberglass: Multiple laminations of glass-fiber-reinforced polyester resin with UV-light stable, colorfast, nonfading, weather- and stain-resistant, colored polyester gel coat, and manufacturer's standard finish.
- 6. Plastic: Color impregnated, color and UV-light stabilized, and mold resistant.
  - a. Polyethylene: Fabricated from virgin plastic HDPE resin.
  - b. Recycled Polyethylene: Fabricated from not less than 96 percent recycled, purified, fractional-melt plastic resin with not less than 90 percent recycled postconsumer waste by weight HDPE.
- 7. Anchors, Fasteners, Fittings, and Hardware: Stainless steel **OR** Brass **OR** Galvanized steel **OR** Zinc-plated steel **OR** Manufacturer's standard, corrosion-resistant-coated or noncorrodible materials, **as directed**; commercial quality, tamperproof, vandal and theft resistant **OR** concealed, recessed, and capped or plugged, **as directed**.
  - a. Angle Anchors: For inconspicuously bolting legs of site furnishings to on **OR** below, **as directed** -grade substrate; one per leg **OR** extent as indicated, **as directed**.
  - b. Antitheft Hold-Down Brackets: For securing site furnishings to substrate; two per unit **OR** extent as indicated on Drawings, **as directed**.
- 8. Nonshrink, Nonmetallic Grout: Premixed, factory-packaged, nonstaining, noncorrosive, nongaseous grout complying with ASTM C 1107; recommended in writing by manufacturer, for exterior applications.
- 9. Erosion-Resistant Anchoring Cement: Factory-packaged, nonshrink, nonstaining, hydraulic-controlled expansion cement formulation for mixing with potable water at Project site to create pourable anchoring, patching, and grouting compound; resistant to erosion from water exposure without needing protection by a sealer or waterproof coating; recommended in writing by manufacturer, for exterior applications.
- 10. Galvanizing: Where indicated for steel and iron components, provide the following protective zinc coating applied to components after fabrication:
  - a. Zinc-Coated Tubing: External, zinc with organic overcoat, consisting of a minimum of **0.9 oz./sq. ft. (0.27 kg/sq. m)** of zinc after welding, a chromate conversion coating, and a clear,

- polymer film. Internal, same as external or consisting of 81 percent zinc pigmented coating, not less than **0.3 mil (0.0076 mm)** thick.
- b. Hot-Dip Galvanizing: According to ASTM A 123/A 123M, ASTM A 153/A 153M, or ASTM A 924/A 924M.
- B. Seating And Tables
1. Frame: Cast aluminum **OR** Cast iron **OR** Steel **OR** Stainless steel **OR** Wrought iron **OR** Cedar **OR** Teak, **as directed**.
  2. Seat **OR** Seat and Back, **as directed**:
    - a. Material:
      - 1) Aluminum Sheet: Perforated **OR** Expanded, **as directed**, metal.
      - 2) Steel **OR** Painted Steel, **as directed**: Perforated metal **OR** Expanded metal **OR** Evenly spaced, parallel flat straps or bars **OR** Evenly woven, flat straps or bars **OR** Edge framed, evenly spaced, parallel rods or rolled bars, **as directed**.
      - 3) Stainless Steel: Perforated metal **OR** Expanded metal **OR** Evenly spaced, parallel flat straps or bars **OR** Evenly woven, flat straps or bars **OR** Edge framed, evenly spaced, parallel rods or rolled bars, **as directed**.
      - 4) Wood: Douglas fir **OR** Pine **OR** Cedar **OR** Redwood **OR** Teak, **as directed**; formed into evenly spaced parallel slats **OR** planks, **as directed**.
      - 5) Recycled **OR** Plastic **OR** fiberglass, **as directed**, Planks: Evenly spaced, parallel.
      - 6) Recycled **OR** Plastic **OR** Fiberglass, **as directed**, Sheet: Solid **OR** Perforated, **as directed**.
    - b. Seat Height: As indicated.
    - c. Seat Surface Shape: Flat **OR** Contoured or dished, **as directed**.
    - d. Overall Height: As indicated.
    - e. Overall Width: As indicated.
    - f. Overall Depth: As indicated.
    - g. Arms: None **OR** One, as indicated **OR** Two, one at each end **OR** Three, one at each end and in center, **as directed**.
      - 1) Arm Material: Match frame **OR** seat, **as directed**.
    - h. Seating Configuration: Multiple units as indicated.
      - 1) Straight **OR** Angled **OR** Curved, **as directed**, shape.
      - 2) Closed hexagon **OR** circle **OR** shape indicated, **as directed**, around a tree trunk **OR** planter **OR** light post, **as directed**.
  3. Table Top:
    - a. Material:
      - 1) Aluminum Sheet: Perforated **OR** Expanded, **as directed**, metal.
      - 2) Steel **OR** Painted Steel, **as directed**: Perforated metal **OR** Expanded metal **OR** Evenly spaced, parallel flat straps or bars **OR** Evenly woven, flat straps or bars **OR** Edge framed, evenly spaced, parallel rods or rolled bars, **as directed**.
      - 3) Stainless Steel: Perforated metal **OR** Expanded metal **OR** Evenly spaced, parallel flat straps or bars **OR** Evenly woven, flat straps or bars **OR** Edge framed, evenly spaced, parallel rods or rolled bars, **as directed**.
      - 4) Wood: Douglas fir **OR** Pine **OR** Cedar **OR** Redwood **OR** Teak, **as directed**; formed into evenly spaced parallel slats **OR** planks, **as directed**.
      - 5) Recycled **OR** Plastic **OR** Fiberglass, **as directed**, Planks: Evenly spaced, parallel.
      - 6) Recycled **OR** Plastic **OR** Fiberglass, **as directed**, Sheet: Solid **OR** Perforated, **as directed**.
    - b. Surface Shape: Round **OR** Hexagon **OR** Shape indicated, **as directed**.
    - c. Feature: Center umbrella hole.
  4. Aluminum Finish: Mill finish **OR** Color coated, **as directed**.
    - a. Color: As selected from manufacturer's full range.
  5. Steel Finish: Galvanized and color **OR** PVC-color, **as directed**, coated.
    - a. Color: As selected from manufacturer's full range.
  6. Stainless-Steel Finish: Dull Satin No. 6.



7. Wood Finish: Unfinished **OR** Factory-applied transparent finish **OR** Factory-applied stain and transparent finish **OR** Factory-applied opaque finish **OR** Manufacturer's standard finish, **as directed**.
  - a. Stain: Manufacturer's standard.
8. Fiberglass **OR** HDPE, **as directed**, Color: As selected from manufacturer's full range.
9. Graphics: Surface-applied **OR** Engraved **OR** Attached brass plaque with engraved, **as directed**, copy, content, and style per manufacturer's standard **OR** as indicated on Drawings, **as directed**.

#### C. Bicycle Racks

1. Bicycle Rack Construction:
  - a. Frame: Aluminum **OR** Steel **OR** Galvanized steel **OR** Stainless steel **OR** Steel and redwood **OR** Steel and pine, **as directed**.
    - 1) Pipe **OR** Tubing, **as directed**, OD: Not less than 1-5/8 inches (41 mm) **OR** 2-3/8 inches (60 mm) **OR** 2-7/8 inches (73 mm) **OR** 4-1/2 inches (115 mm), **as directed**.
    - 2) Locking Bars: Solid round bar, not less than 3/4 inch (19 mm) **OR** 1 inch (25 mm), **as directed**, in diameter.
  - b. Style: Single-side parking **OR** Double-side parking **OR** Bollard **OR** As indicated, **as directed**.
    - 1) Capacity: Designed to accommodate no fewer than two **OR** three **OR** four, **as directed**, bicycles.
  - c. Security: Designed to lock wheel and frame.
  - d. Accessories: Base covers for each pipe and tubing anchored end **OR** Wheel stops, **as directed**.
  - e. Installation Method: Freestanding **OR** Surface flange anchored at finished grade to substrate indicated **OR** Surface flange anchored below finished grade to substrate indicated **OR** Cast in concrete **OR** Bolted to cast-in anchor bolts **OR** Wall mounted **OR** As indicated, **as directed**.
2. Aluminum Finish: Mill finish **OR** Color coated, **as directed**.
  - a. Color: As selected from manufacturer's full range.
3. Steel Finish: Galvanized **OR** Color coated, **as directed**.
  - a. Color: As selected from manufacturer's full range.
4. Stainless-Steel Finish: Directional Satin No. 4.
5. Wood Finish: Unfinished **OR** Manufacturer's standard finish, **as directed**.

#### D. Bicycle Lockers

1. Bicycle Locker Construction:
  - a. Locker: Molded one-piece fiberglass **OR** Sheet steel, 0.053 inch (1.4 mm) thick, **OR** Sheet steel, 0.053 inch (1.4 mm) thick, with perforated metal sides, **as directed**, with welded tubular steel frame.
  - b. Door: Molded one-piece fiberglass **OR** Sheet steel, 0.053 inch (1.4 mm) thick, **as directed**, with tubular steel frame **OR** Match locker, **as directed**.
  - c. View Window **OR** Grille, **as directed**: Lexan, 12 inches (305 mm) square **OR** Perforated metal, **as directed**.
  - d. Lock: Manufacturer's standard **OR** Key lock with internal locking bar **OR** Coin/token lock, **as directed**.
    - 1) Provide four keys.
  - e. Overall Height: As indicated.
  - f. Overall Width: As indicated.
  - g. Overall Depth: As indicated.
  - h. Capacity: Designed to accommodate one **OR** two, **as directed**, bicycle(s).
  - i. Installation Method: Locker anchored at finished grade to substrate indicated **OR** Locker anchored below finished grade to substrate indicated **OR** As indicated, **as directed**.
  - j. Locker Configuration: Multiple **OR** Four, **as directed**, units as indicated, in straight row **OR** curved shape **OR** shape indicated, **as directed**.
2. Steel Finish: Color coated.



- a. Color: As selected from manufacturer's full range.
3. Fiberglass Color: As selected from manufacturer's full range.
- E. Trash And Ash Receptacles
  1. Aluminum Facing Surrounds: Aluminum sheet **OR** Perforated aluminum sheet **OR** Grid in tubular frame **OR** Evenly patterned, parallel flat aluminum straps, bars, or tubular shapes **OR** Match benches, **as directed**.
  2. Steel Facing Surrounds: Steel sheet **OR** Perforated-steel sheet **OR** Evenly patterned, parallel flat steel straps, bars, or tubular shapes **OR** Evenly patterned, parallel round steel rods, bars, or tubular shapes **OR** Grid in tubular frame **OR** Match benches, **as directed**.
  3. Stainless-Steel Facing Surrounds: Steel sheet **OR** Perforated-steel sheet **OR** Evenly patterned, parallel flat steel straps, bars, or tubular shapes **OR** Evenly patterned, parallel round steel rods, bars, or tubular shapes **OR** Grid in tubular frame **OR** Match benches, **as directed**.
  4. Wood Facing Surrounds: Evenly spaced, Douglas fir slats **OR** Evenly spaced pine slats **OR** Evenly spaced cedar slats **OR** Redwood panels **OR** Evenly spaced redwood slats **OR** Teak panels **OR** Evenly spaced teak slats **OR** Match benches, **as directed**.
  5. Fiberglass Facing Surrounds: Molded fiberglass shape.
  6. Plastic Facing Surrounds: Molded HDPE shape **OR** Evenly spaced HDPE slats **OR** Evenly spaced, recycled HDPE slats **OR** Match benches, **as directed**.
  7. Support Frames: Steel **OR** Galvanized steel, **as directed**; welded.
  8. Trash and Ash Receptacles:
    - a. Receptacle Shape and Form: Round cylinder **OR** Round cylinder with tapered funnel top **OR** Round, tapered column **OR** Square column **OR** Rectangular column **OR** As indicated, **as directed**; with opening for depositing trash in lid or top **OR** side of lid or top **OR** receptacle side, **as directed**.
    - b. Ash Receptacle Function: Uncovered receptacle with sand pan **OR** Uncovered receptacle with bowl and funnel **OR** Covered receptacle with sand pan **OR** Covered receptacle with bowl and screen **OR** Covered receptacle with slots **OR** Uncovered receptacle with sand pan attaching to side of trash receptacle, **as directed**, for depositing cigarette butts; fire-proof design; bowl and pan removable for cleaning.
    - c. Lids and Tops: Matching facing panels **OR** Aluminum **OR** Steel **OR** HDPE **OR** Recycled HDPE, **as directed**, secured by cable or chain, hinged, swiveled, or permanently secured.
      - 1) Description: Flat rim ring lid with center opening **OR** Dome top **OR** Arched top **OR** Elevated flat or shallow dome rain-cap lid **OR** Combination ash sand pan and rim lid **OR** Combination ash sand pan and dome top **OR** Combination ash sand pan and elevated flat or shallow dome rain-cap lid, **as directed**.
      - 2) Opening for depositing trash covered by self-closing, spring-loaded-hinged, push-in **OR** rotating, **as directed**, weather flap.
    - d. Inner Container: Aluminum **OR** Galvanized steel sheet **OR** Perforated-metal **OR** Fiberglass **OR** Rigid plastic, **as directed**, container with drain holes **OR** lift-out handles, **as directed**; designed to be removable and reusable.
    - e. Disposable Liners: Provide receptacle designed to accommodate disposable liners.
    - f. Capacity: Not less than 22 gal. (83 L) **OR** 28 gal. (106 L) **OR** 30 gal. (114 L) **OR** 32 gal. (121 L) **OR** 40 gal. (151 L) **OR** 55 gal. (208 L), **as directed**.
    - g. Service Access: Removable lid or top **OR** Fixed lid or top, side access, **as directed**; inner container and disposable liner lift or slide out for emptying; lockable with padlock hasps **OR** keyed lock with two keys per receptacle **OR** self-latching hinge, **as directed**.
    - h. Post Mount: Color-coated steel pipe; color to match receptacle **OR** Galvanized steel pipe **OR** Wood, **as directed**; for mounting one **OR** two **OR** three, **as directed**, receptacle(s).
    - i. Ash Receptacle Accessories: Sand sifter **OR** Butt stub-out, **as directed**.
  9. Aluminum Finish: Mill finish **OR** Color coated, **as directed**.
    - a. Color: As selected from manufacturer's full range.
  10. Steel Finish: Galvanized and color **OR** PVC-color, **as directed**, coated.
    - a. Color: As selected from manufacturer's full range.
  11. Stainless-Steel Finish: Dull Satin No. 6.





12. Wood Finish: Unfinished **OR** Factory-applied transparent finish **OR** Factory-applied stain and transparent finish **OR** Factory-applied opaque finish **OR** Manufacturer's standard finish, **as directed**.
  - a. Stain: Manufacturer's standard.
13. Fiberglass **OR** HDPE, **as directed**, Color: As selected from manufacturer's full range.
14. Graphics: Surface-applied **OR** Engraved **OR** Attached brass plaque with engraved, **as directed**, copy, content, and style per manufacturer's standard **OR** as indicated on Drawings, **as directed**.
  - a. Copy: Litter **OR** Trash **OR** Waste **OR** Recycle, **as directed**.

#### F. Planters

1. Aluminum Facing Surrounds: Aluminum sheet **OR** Perforated aluminum sheet **OR** Grid in tubular frame **OR** Evenly patterned, parallel flat aluminum, **as directed**, straps, bars, or tubular shapes **OR** Match benches, **as directed**.
2. Steel Facing Surrounds: Steel sheet **OR** Perforated-steel sheet **OR** Evenly patterned, parallel flat steel straps, bars, or tubular shapes **OR** Evenly patterned, parallel round steel rods, bars, or tubular shapes **OR** Grid in tubular frame **OR** Match benches, **as directed**.
3. Stainless-Steel Facing Surrounds: Steel sheet **OR** Perforated-steel sheet **OR** Evenly patterned, parallel flat steel straps, bars, or tubular shapes **OR** Evenly patterned, parallel round steel rods, bars, or tubular shapes **OR** Grid in tubular frame **OR** Match benches, **as directed**.
4. Wood Facing Surrounds: Evenly spaced, Douglas fir slats **OR** Evenly spaced pine slats **OR** Evenly spaced cedar slats **OR** Redwood panels **OR** Evenly spaced redwood slats **OR** Teak panels **OR** Evenly spaced teak slats **OR** Match benches, **as directed**.
5. Fiberglass Facing Surrounds: Molded fiberglass shape.
6. Plastic Facing Surrounds: Molded HDPE shape **OR** Evenly spaced HDPE slats **OR** Evenly spaced, recycled HDPE slats **OR** Match benches, **as directed**.
7. Support Frames: Steel **OR** Galvanized steel, **as directed**; welded.
8. Planter Shape and Form: Round cylinder **OR** Round cylinder with tapered funnel top **OR** Round, tapered column **OR** Square column **OR** Rectangular column **OR** As indicated, **as directed**.
9. Style: To match benches **OR** As indicated by manufacturer's designation, **as directed**.
10. Inner Container: Aluminum **OR** Galvanized steel sheet **OR** Fiberglass **OR** Rigid plastic, **as directed**, container with drain holes.
11. Capacity: Not less than 22 gal. (83 L) **OR** 28 gal. (106 L) **OR** 30 gal. (114 L) **OR** 32 gal. (121 L) **OR** 40 gal. (151 L) **OR** 55 gal. (208 L), **as directed**.
12. Installation Method: Freestanding **OR** Freestanding with weighted base **OR** Anchored to substrate indicated on Drawings **OR** Wall mounted **OR** Post mounted **OR** Mounted on elevated leg angles anchored at finished grade to substrate indicated on Drawings **OR** Mounted on elevated leg angles anchored below finished grade to substrate indicated on Drawings **OR** As indicated on Drawings, **as directed**.
  - a. Post Mount: Color-coated steel pipe; color to match receptacle **OR** Galvanized steel pipe **OR** Wood, **as directed**; for mounting one **OR** two **OR** three, **as directed**, planter(s).
13. Aluminum Finish: Color coated.
  - a. Color: As selected from manufacturer's full range.
14. Steel Finish: Galvanized and color **OR** PVC-color, **as directed**, coated.
  - a. Color: As selected from manufacturer's full range.
15. Stainless-Steel Finish: Dull Satin No. 6.
16. Wood Finish: Unfinished **OR** Factory-applied transparent finish **OR** Factory-applied stained and transparent finish, **as directed**.
17. Fiberglass **OR** HDPE, **as directed**, Color: As selected from manufacturer's full range.
  - a. Finish: Smooth **OR** Textured, **as directed**.

#### G. Bollards

1. Bollard Construction:
  - a. Pipe **OR** Tubing **OR** Cast, **as directed** OD: Not less than 4-1/2 inches (115 mm), fluted, **as directed**.
    - 1) Steel: Schedule 40 **OR** 80, **as directed**, pipe.

- 2) Aluminum: Extruded pipe and tubes **OR** Castings, **as directed**.
  - 3) Stainless Steel: Tubes **OR** Pipe, **as directed**.
  - 4) Cast Iron: Tapered **OR** As indicated, **as directed**.
  - b. Round **OR** Square, **as directed**, Wood: Cedar, **8 inches (203 mm)** square **OR** **10 inches (254 mm)** in diameter, **as directed**.
  - c. Style: Manufacturer's standard **OR** Chamfered top **OR** Dome top **OR** Ornamental cap **OR** As indicated, **as directed**.
  - d. Accessories: Eye bolts.
  - e. Installation Method: Surface flange anchored at finished grade to substrate indicated **OR** Surface flange anchored below finished grade to substrate indicated **OR** Cast in concrete **OR** Bolted to cast-in anchor bolts **OR** As indicated, **as directed**.
  2. Aluminum Finish: Mill finish **OR** Color coated, **as directed**.
    - a. Color: As selected from manufacturer's full range.
  3. Steel Finish: Galvanized **OR** Color coated, **as directed**.
    - a. Color: As selected from manufacturer's full range.
  4. Cast-Iron Finish: Manufacturer's standard **OR** Galvanized **OR** Color coated, **as directed**.
    - a. Color: As selected from manufacturer's full range.
  5. Stainless-Steel Finish: Directional Satin No. 4.
  6. Wood Finish: Unfinished **OR** Manufacturer's standard finish, **as directed**.
- H. Fabrication
1. Metal Components: Form to required shapes and sizes with true, consistent curves, lines, and angles. Separate metals from dissimilar materials to prevent electrolytic action.
  2. Welded Connections: Weld connections continuously. Weld solid members with full-length, full-penetration welds and hollow members with full-circumference welds. At exposed connections, finish surfaces smooth and blended so no roughness or unevenness shows after finishing and welded surface matches contours of adjoining surfaces.
  3. Pipes and Tubes: Form simple and compound curves by bending members in jigs to produce uniform curvature for each repetitive configuration required; maintain cylindrical cross section of member throughout entire bend without buckling, twisting, cracking, or otherwise deforming exposed surfaces of handrail and railing components.
  4. Preservative-Treated Wood Components: Complete fabrication of treated items before treatment if possible. If cut after treatment, apply field treatment complying with AWPA M4 to cut surfaces.
  5. Exposed Surfaces: Polished, sanded, or otherwise finished; all surfaces smooth, free of burrs, barbs, splinters, and sharpness; all edges and ends rolled, rounded, or capped.
  6. Factory Assembly: Assemble components in the factory to greatest extent possible to minimize field assembly. Clearly mark units for assembly in the field.
- I. Finishes, General
1. Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
  2. Appearance of Finished Work: Variations in appearance of abutting or adjacent pieces are acceptable if they are within one-half of the range of approved Samples. Noticeable variations in the same piece are not acceptable. Variations in appearance of other components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- J. Aluminum Finishes
1. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.
- K. Steel And Galvanized Steel Finishes
1. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

2. PVC Finish: Manufacturer's standard, UV-light stabilized, mold-resistant, slip-resistant, matte-textured, dipped or sprayed-on, PVC-plastisol finish, with flame retardant added; complying with coating manufacturer's written instructions for pretreatment, application, and minimum dry film thickness.

L. Iron Finishes

1. Baked-Enamel, Powder-Coat Finish: Manufacturer's standard, baked, polyester, powder-coat finish complying with finish manufacturer's written instructions for surface preparation, including pretreatment, application, baking, and minimum dry film thickness.

M. Stainless-Steel Finishes

1. Remove tool and die marks and stretch lines or blend into finish.
2. Grind and polish surfaces to produce uniform, directionally textured, polished finish indicated, free of cross scratches. Run grain with long dimension of each piece.

### 1.3 EXECUTION

A. Installation, General

1. Comply with manufacturer's written installation instructions unless more stringent requirements are indicated. Complete field assembly of site furnishings where required.
2. Unless otherwise indicated, install site furnishings after landscaping and paving have been completed.
3. Install site furnishings level, plumb, true, and securely anchored **OR** positioned, **as directed**, at locations indicated on Drawings.
4. Post Setting: Set cast-in support posts in concrete footing with smooth top, shaped to shed water. Protect portion of posts above footing from concrete splatter. Verify that posts are set plumb or at correct angle and are aligned and at correct height and spacing. Hold posts in position during placement and finishing operations until concrete is sufficiently cured.
5. Posts Set into Voids in Concrete: Form or core-drill holes for installing posts in concrete to depth recommended in writing by manufacturer of site furnishings and **3/4 inch (19 mm)** larger than OD of post. Clean holes of loose material, insert posts, and fill annular space between post and concrete with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.
6. Pipe Sleeves: Use steel pipe sleeves preset and anchored into concrete for installing posts. After posts have been inserted into sleeves, fill annular space between post and sleeve with nonshrink, nonmetallic grout or anchoring cement, mixed and placed to comply with anchoring material manufacturer's written instructions, with top smoothed and shaped to shed water.

B. Cleaning

1. After completing site furnishing installation, inspect components. Remove spots, dirt, and debris. Repair damaged finishes to match original finish or replace component.

END OF SECTION 32 33 23 00



Task	Specification	Specification Description
32 33 23 00	01 22 16 00	No Specification Required
32 33 23 00	32 33 13 00	Miscellaneous Site and Street Furnishings
32 33 33 00	32 33 23 00	Site Furnishings
32 33 33 00	32 33 13 00	Miscellaneous Site and Street Furnishings
32 33 43 13	32 33 23 00	Site Furnishings
32 33 43 53	32 33 13 00	Miscellaneous Site and Street Furnishings
32 33 53 00	01 22 16 00	No Specification Required
32 39 23 00	32 33 13 00	Miscellaneous Site and Street Furnishings
32 84 00 00	07 21 13 13	Modified Bitumous Protected Membrane Roofing

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## SECTION 32 84 13 00 - IRRIGATION SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for irrigation systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Piping.
  - b. Encasement for piping.
  - c. Manual valves.
  - d. Pressure-reducing valves.
  - e. Automatic control valves.
  - f. Automatic drain valves.
  - g. Transition fittings.
  - h. Dielectric fittings.
  - i. Miscellaneous piping specialties.
  - j. Sprinklers.
  - k. Quick couplers.
  - l. Drip irrigation specialties.
  - m. Controllers.
  - n. Boxes for automatic control valves.

#### C. Definitions

1. Circuit Piping: Downstream from control valves to sprinklers, specialties, and drain valves. Piping is under pressure during flow.
2. Drain Piping: Downstream from circuit-piping drain valves. Piping is not under pressure.
3. Main Piping: Downstream from point of connection to water distribution piping to, and including, control valves. Piping is under water-distribution-system pressure.
4. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.

#### D. Performance Requirements

1. Irrigation zone control shall be automatic operation with controller and automatic control **OR** manual operation with manual, **as directed**, valves.
2. Location of Sprinklers and Specialties: Design location is approximate. Make minor adjustments necessary to avoid plantings and obstructions such as signs and light standards. Maintain 100 percent irrigation coverage of areas indicated.
3. Delegated Design: Design 100 percent coverage irrigation system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
  - a. Available land records indicate the following soil conditions:
    - 1) Type: Coarse **OR** Medium **OR** Fine, **as directed**.
    - 2) Texture:
      - a) Sand: as directed by the Owner.
      - b) Silt: as directed by the Owner .
      - c) Clay: as directed by the Owner.
    - 3) Particle Size:
      - a) Sand: as directed by the Owner.
      - b) Silt: as directed by the Owner.



- c) Clay: as directed by the Owner.
- 4) Structure: Single grained **OR** Granular **OR** Platy **OR** Blocky, **as directed**.
- 5) Density: as directed by the Owner.
- 6) Moisture Content: as directed by the Owner.
- 7) Infiltration Rate: as directed by the Owner.
- 4. Minimum Working Pressures: The following are minimum pressure requirements for piping, valves, and specialties unless otherwise indicated:
  - a. Irrigation Main Piping: **200 psig (1380 kPa)**.
  - b. Circuit Piping: **150 psig (1035 kPa)**.

#### E. Submittals

- 1. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- 2. Wiring Diagrams: For power, signal, and control wiring.
- 3. Delegated-Design Submittal: For irrigation systems indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- 4. Zoning Chart: Show each irrigation zone and its control valve.
- 5. Controller Timing Schedule: Indicate timing settings for each automatic controller zone.
- 6. Field quality-control reports.
- 7. Operation and maintenance data.

#### F. Quality Assurance

- 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

#### G. Delivery, Storage, And Handling

- 1. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
- 2. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

#### H. Project Conditions

- 1. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed interruption of water service.
  - b. Do not proceed with interruption of water service without the Owner's written permission.

### 1.2 PRODUCTS

#### A. Pipes, Tubes, And Fittings

- 1. Comply with requirements in the piping schedule for applications of pipe, tube, and fitting materials, and for joining methods for specific services, service locations, and pipe sizes.
- 2. Galvanized-Steel Pipe: ASTM A 53/A 53M, Standard Weight, Type E, Grade B.
  - a. Galvanized-Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106/A 106M, Standard Weight, seamless-steel pipe with threaded ends.
  - b. Galvanized, Gray-Iron Threaded Fittings: ASME B16.4, Class 125, standard pattern.
  - c. Malleable-Iron Unions: ASME B16.39, Class 150, hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface, and female threaded ends.
  - d. Cast-Iron Flanges: ASME B16.1, Class 125.
- 3. Ductile-Iron Pipe with Mechanical Joints: AWWA C151, with mechanical-joint bell and spigot ends.



- a. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
      - 1) Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron glands, rubber gaskets, and steel bolts.
  4. Ductile-Iron Pipe with Push-on Joint: AWWA C151, with push-on-joint bell and spigot ends.
    - a. Push-on-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern.
      - 1) Gaskets: AWWA C111, rubber.
  5. Soft Copper Tube: **ASTM B 88, Type L (ASTM B 88M, Type B)**, water tube, annealed temper.
    - a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
    - b. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
    - c. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
  6. Hard Copper Tube: **ASTM B 88, Type L (ASTM B 88M, Type B)**, and **ASTM B 88, Type M (ASTM B 88M, Type C)**, water tube, drawn temper.
    - a. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper solder-joint fittings. Furnish wrought-copper fittings if indicated.
    - b. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end.
    - c. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
  7. PE Pipe with Controlled ID: ASTM F 771, PE 3408 compound; SDR 11.5 and SDR 15.
    - a. Insert Fittings for PE Pipe: ASTM D 2609, nylon or propylene plastic with barbed ends. Include bands or other fasteners.
  8. PE Pipe with Controlled OD: ASTM F 771, PE 3408 compound, SDR 11.
    - a. PE Butt, Heat-Fusion Fittings: ASTM D 3261.
    - b. PE Socket-Type Fittings: ASTM D 2683.
  9. PE Pressure Pipe: AWWA C906, with DR of 7.3, 9, or 9.3 and PE compound number required to give pressure rating not less than **160 psig (1100 kPa) OR 200 psig (1380 kPa), as directed**.
    - a. PE Butt, Heat-Fusion Fittings: ASTM D 3261.
    - b. PE Socket-Type Fittings: ASTM D 2683.
  10. PVC Pipe: ASTM D 1785, PVC 1120 compound, Schedule 40 **OR** Schedule 80, **as directed**.
    - a. PVC Socket Fittings: ASTM D 2466, Schedule 40 **OR** Schedule 80, **as directed**.
    - b. PVC Threaded Fittings: ASTM D 2464, Schedule 80.
    - c. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket ends.
  11. PVC Pipe, Pressure Rated: ASTM D 2241, PVC 1120 compound, SDR 21 and SDR 26.
    - a. PVC Socket Fittings: ASTM D 2467, Schedule 80.
    - b. PVC Socket Unions: Construction similar to MSS SP-107, except both headpiece and tailpiece shall be PVC with socket or threaded ends.
- B. Piping Joining Materials
  1. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, **1/8 inch (3.2 mm)** thick unless otherwise indicated; full-face or ring type unless otherwise indicated.
  2. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
  3. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.
  4. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
  5. Solvent Cements for Joining PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
  6. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer unless otherwise indicated.
- C. Encasement For Piping
  1. Standard: ASTM A 674 or AWWA C105.



2. Form: Sheet **OR** Tube, **as directed**.
3. Material: LLDPE film of **0.008-inch (0.20-mm)** **OR** LLDPE film of **0.008-inch (0.20-mm)** minimum thickness or high-density, cross-laminated PE film of **0.004-inch (0.10-mm)** **OR** High-density, cross-laminated PE film of **0.004-inch (0.10-mm)**, **as directed**, minimum thickness.
4. Color: Black **OR** Natural, **as directed**.

#### D. Manual Valves

1. Curb Valves:
  - a. Description:
    - 1) Standard: AWWA C800.
    - 2) **NPS 1 (DN 25)** and Smaller Pressure Rating: **100 psig (690 kPa)** minimum **OR 150 psig (1035 kPa)**, **as directed**.
    - 3) **NPS 1-1/4 to NPS 2 (DN 32 to DN 50)** Pressure Rating: **80 psig (550 kPa)** minimum **OR 150 psig (1035 kPa)**, **as directed**.
    - 4) Body Material: Brass or bronze with ball or ground-key plug.
    - 5) End Connections: Matching piping.
    - 6) Stem: With wide-tee head.
2. Curb-Valve Casing:
  - a. Standard: Similar to AWWA M44 for cast-iron valve casings.
  - b. Top Section: Telescoping, of length required for depth of burial of curb valve.
  - c. Barrel: Approximately **3-inch (75-mm)** diameter.
  - d. Plug: With lettering "WATER."
  - e. Bottom Section: With base of size to fit over valve.
  - f. Base Support: Concrete collar **OR** wood frame, **as directed**.
3. Shutoff Rods for Curb-Valve Casings: Furnish one **OR** two, **as directed**, steel, tee-handle shutoff rod(s) with one pointed end, stem of length to operate deepest buried valve, and slotted end matching curb valve for Project.
4. Brass Ball Valves:
  - a. Description:
    - 1) Standard: MSS SP-110.
    - 2) SWP Rating: **150 psig (1035 kPa)**.
    - 3) CWP Rating: **600 psig (4140 kPa)**.
    - 4) Body Design: Two piece.
    - 5) Body Material: Forged brass.
    - 6) Ends: Threaded or solder joint if indicated.
    - 7) Seats: PTFE or TFE.
    - 8) Stem: Brass.
    - 9) Ball: Chrome-plated brass.
    - 10) Port: Full **OR** regular, but not reduced, **as directed**.
5. Bronze Ball Valves:
  - a. Description:
    - 1) Standard: MSS SP-110.
    - 2) SWP Rating: **150 psig (1035 kPa)**.
    - 3) CWP Rating: **600 psig (4140 kPa)**.
    - 4) Body Design: Two piece.
    - 5) Body Material: Bronze.
    - 6) Ends: Threaded or solder joint if indicated.
    - 7) Seats: PTFE or TFE.
    - 8) Stem: Bronze.
    - 9) Ball: Chrome-plated brass.
    - 10) Port: Full **OR** regular, but not reduced, **as directed**.
6. Iron Ball Valves:
  - a. Description:
    - 1) Standard: MSS SP-72.
    - 2) CWP Rating: **200 psig (1380 kPa)**.

- 3) Body Design: Split body.
- 4) Body Material: ASTM A 126, gray iron.
- 5) Ends: Flanged.
- 6) Seats: PTFE or TFE.
- 7) Stem: Stainless steel.
- 8) Ball: Stainless steel.
- 9) Port: Full.
7. Plastic Ball Valves:
  - a. Description:
    - 1) Standard: MSS SP-122.
    - 2) Pressure Rating: 125 psig (860 kPa) minimum OR 150 psig (1035 kPa), as directed.
    - 3) Body Material: PVC.
    - 4) Type: Union.
    - 5) End Connections: Socket or threaded.
    - 6) Port: Full.
8. Bronze Gate Valves:
  - a. Description:
    - 1) Standard: MSS SP-80, Type 2.
    - 2) Class: 125.
    - 3) CWP Rating: 200 psig (1380 kPa).
    - 4) Body Material: ASTM B 62 bronze with integral seat and screw-in bonnet.
    - 5) Ends: Threaded or solder joint.
    - 6) Stem: Bronze, nonrising.
    - 7) Disc: Solid wedge, bronze.
    - 8) Packing: Asbestos free.
    - 9) Handwheel: Malleable iron, bronze, or aluminum.
9. Iron Gate Valves, Resilient Seated:
  - a. Description:
    - 1) Standard: AWWA C509.
    - 2) Pressure Rating: 200 psig (1380 kPa) OR 250 psig (1725 kPa), as directed, minimum.
    - 3) Body Material: Ductile or gray iron with bronze trim.
    - 4) End Connections: Mechanical joint or push-on joint.
    - 5) Interior Coating: Comply with AWWA C550.
    - 6) Body Design: Nonrising stem.
    - 7) Operator: Stem nut.
    - 8) Disc: Solid wedge with resilient coating.
10. Iron Gate Valve Casings:
  - a. Standard: AWWA M44 for cast-iron valve casings.
  - b. Top Section: Adjustable extension of length required for depth of burial of valve.
  - c. Barrel: Approximately 5-inch (125-mm) diameter.
  - d. Plug: With lettering "WATER."
  - e. Bottom Section: With base of size to fit over valve.
  - f. Base Support: Concrete collar OR wood frame, as directed.
11. Operating Wrenches for Iron Gate Valve Casings: Furnish one OR two, as directed, steel, tee-handle operating wrench(es) with one pointed end, stem of length to operate deepest buried valve, and socket matching valve operating nut for Project.
12. Iron Gate Valves, NRS:
  - a. Description:
    - 1) Standard: MSS SP-70, Type I.
    - 2) CWP Rating: 200 psig (1380 kPa).
    - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
    - 4) Ends: Flanged.
    - 5) Trim: All bronze.
    - 6) Disc: Solid wedge.

- 7) Packing and Gasket: Asbestos free.
13. Iron Gate Valves, OS&Y:
  - a. Description:
    - 1) Standard: MSS SP-70, Type I.
    - 2) CWP Rating: 200 psig (1380 kPa).
    - 3) Body Material: ASTM A 126, gray iron with bolted bonnet.
    - 4) Ends: Flanged.
    - 5) Trim: All bronze.
    - 6) Disc: Solid wedge.
    - 7) Packing and Gasket: Asbestos free.
- E. Pressure-Reducing Valves
  1. Water Regulators:
    - a. Description:
      - 1) Standard: ASSE 1003.
      - 2) Body Material: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
      - 3) Pressure Rating: Initial pressure of 150 psig (1035 kPa).
      - 4) End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
  2. Water Control Valves:
    - a. Description: Pilot-operation, diaphragm-type, single-seated main water control valve. Include small pilot control valve, restrictor device, specialty fittings, and sensor piping.
      - 1) Main Valve Body: Cast- or ductile-iron body with AWWA C550 or FDA-approved, interior epoxy coating; or stainless-steel body.
      - 2) Pattern: Angle-valve OR Globe-valve, as directed, design.
      - 3) Trim: Stainless steel.
      - 4) Pressure Rating: Initial pressure of 150 psig (1035 kPa) minimum.
      - 5) End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 (DN 65) and larger.
- F. Automatic Control Valves
  1. Bronze, Automatic Control Valves:
    - a. Description: Cast-bronze body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.
  2. Plastic, Automatic Control Valves:
    - a. Description: Molded-plastic body, normally closed, diaphragm type with manual-flow adjustment, and operated by 24-V ac solenoid.
- G. Automatic Drain Valves
  1. Description: Spring-loaded-ball type of corrosion-resistant construction and designed to open for drainage if line pressure drops below 2-1/2 to 3 psig (17 to 20 kPa).
- H. Transition Fittings
  1. General Requirements: Same size as, and with pressure rating at least equal to and with ends compatible with, piping to be joined.
  2. Transition Couplings:
    - a. Description: AWWA C219, metal sleeve-type coupling for underground pressure piping.
  3. Plastic-to-Metal Transition Fittings:
    - a. Description: PVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-socket or threaded end.
  4. Plastic-to-Metal Transition Unions:

- a. Description: MSS SP-107, PVC four-part union. Include one brass or stainless-steel threaded end, one solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.
- I. Dielectric Fittings
1. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
  2. Dielectric Unions:
    - a. Description: Factory-fabricated union, **NPS 2 (DN 50)** and smaller.
      - 1) Pressure Rating: **150 psig (1035 kPa)** minimum **OR 250 psig (1725 kPa)**, **as directed**, at **180 deg F (82 deg C)**.
      - 2) End Connections: Solder-joint copper alloy and threaded ferrous; threaded ferrous.
  3. Dielectric Flanges:
    - a. Description: Factory-fabricated, bolted, companion-flange assembly, **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)** and larger.
      - 1) Pressure Rating: **150 psig (1035 kPa)** minimum **OR 175 psig (1200 kPa)** minimum **OR 300 psig (2070 kPa)**, **as directed**.
      - 2) End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
  4. Dielectric-Flange Kits:
    - a. Description: Nonconducting materials for field assembly of companion flanges, **NPS 2-1/2 (DN 65)** and larger.
      - 1) Pressure Rating: **150 psig (1035 kPa)** minimum.
      - 2) Gasket: Neoprene or phenolic.
      - 3) Bolt Sleeves: Phenolic or polyethylene.
      - 4) Washers: Phenolic with steel backing washers.
  5. Dielectric Couplings:
    - a. Description: Galvanized-steel coupling.
      - 1) Pressure Rating: **300 psig (2070 kPa)** at **225 deg F (107 deg C)**.
      - 2) End Connections: Female threaded.
      - 3) Lining: Inert and noncorrosive, thermoplastic lining.
  6. Dielectric Nipples:
    - a. Description: Electroplated steel nipple complying with ASTM F 1545.
      - 1) Pressure Rating: **300 psig (2070 kPa)** at **225 deg F (107 deg C)**.
      - 2) End Connections: Male threaded or grooved.
      - 3) Lining: Inert and noncorrosive, propylene.
- J. Miscellaneous Piping Specialties
1. Water Hammer Arresters: ASSE 1010 or PDI WH 201, with bellows or piston-type pressurized cushioning chamber and in sizes complying with PDI WH 201, Sizes A to F.
  2. Pressure Gages: ASME B40.1. Include **4-1/2-inch- (115-mm-)** diameter dial, dial range of two times system operating pressure, and bottom outlet.
- K. Sprinklers
1. General Requirements: Designed for uniform coverage over entire spray area indicated at available water pressure.
  2. Metal, Exposed, Impact-Drive Rotary Sprinklers:
    - a. Description:
      - 1) Construction: Brass and other corrosion-resistant metals.
      - 2) Mounting: Aboveground, exposed on riser.
  3. Plastic, Exposed, Impact-Drive Rotary Sprinklers:
    - a. Description:
      - 1) Construction: ABS and corrosion-resistant metals.
      - 2) Mounting: Aboveground, exposed on riser.
  4. Plastic, Pop-up, Gear-Drive Rotary Sprinklers:

- a. Description:
  - 1) Body Material: ABS.
  - 2) Nozzle: ABS **OR** Brass, **as directed**.
  - 3) Retraction Spring: Stainless steel.
  - 4) Internal Parts: Corrosion resistant.
5. Metal, Pop-up, Impact-Drive Rotary Sprinklers:
  - a. Description:
    - 1) Case: Brass.
    - 2) Body Material: Brass.
    - 3) Pop-up Height: Approximately **3 inches (75 mm)**.
    - 4) Sprinkler Construction: Brass and other corrosion-resistant metals.
6. Plastic, Pop-up, Impact-Drive Rotary Sprinklers:
  - a. Description:
    - 1) Case: ABS.
    - 2) Pop-up Height: Approximately **3 inches (75 mm)**.
    - 3) Sprinkler Construction: ABS and other corrosion-resistant metals.
7. Metal, Surface Spray Sprinklers:
  - a. Description:
    - 1) Body Material and Flange: Brass.
    - 2) Nozzle: Brass.
    - 3) Pattern: Fixed, with flow adjustment.
8. Plastic, Surface Spray Sprinklers:
  - a. Description:
    - 1) Body Material and Flange: ABS.
    - 2) Pattern: Fixed, with flow adjustment.
9. Metal, Surface, Pop-up Spray Sprinklers:
  - a. Description:
    - 1) Body Material and Flange: Brass.
    - 2) Nozzle: Brass.
    - 3) Pattern: Fixed, with flow adjustment.
10. Plastic, Surface, Pop-up Spray Sprinklers:
  - a. Description:
    - 1) Body Material and Flange: ABS.
    - 2) Pattern: Fixed, with flow adjustment.
11. Plastic, Pop-up Spray Sprinklers:
  - a. Description:
    - 1) Body Material: ABS.
    - 2) Nozzle: ABS **OR** Brass, **as directed**.
    - 3) Retraction Spring: Stainless steel.
    - 4) Internal Parts: Corrosion resistant.
    - 5) Pattern: Fixed, with flow adjustment.
12. Metal Shrub Sprinklers:
  - a. Description:
    - 1) Body Material: Brass.
    - 2) Nozzle: Brass.
    - 3) Pattern: Fixed, with flow adjustment.
13. Plastic Shrub Sprinklers:
  - a. Description:
    - 1) Body Material: ABS or other plastic.
    - 2) Pattern: Fixed, with flow adjustment.

L. Quick Couplers

1. Description: Factory-fabricated, bronze or brass, two-piece assembly. Include coupler water-seal valve; removable upper body with spring-loaded or weighted, rubber-covered cap; hose swivel with ASME B1.20.7, 3/4-11.5NH threads for garden hose on outlet; and operating key.

- a. Locking-Top Option: Vandal-resistant locking feature. Include one **OR** two, **as directed**, matching key(s).

M. Drip Irrigation Specialties

1. Freestanding Emitters: Device to deliver water at approximately 20 psig (138 kPa).
  - a. Body Material: PE or vinyl, with flow control.
  - b. Riser to Emitter: PE or PVC flexible tubing.
2. Manifold Emitter Systems: Manifold with tubing and emitters.
  - a. Manifold: With multiple outlets to deliver water to emitters.
    - 1) Body Material: Plastic.
    - 2) Outlet Caps: Plastic, for outlets without installed tubing.
    - 3) Operation: Automatic pressure compensating.
  - b. Tubing: PE or PVC; 1/8-inch (3-mm) minimum ID.
  - c. Emitter: Device to deliver water at approximately 20 psig (138 kPa).
    - 1) Body Material: PE or vinyl, with flow control.
3. Multiple-Outlet Emitter Systems: Emitter with tubing and button-type outlets.
  - a. Emitter: With multiple outlets to deliver water to remote outlets.
    - 1) Body Material: Plastic, with flow control.
    - 2) Outlet Caps: Plastic, for outlets without installed tubing.
    - 3) Operation: Automatic pressure compensating.
    - 4) Emitters: Devices to deliver water at approximately 20 psig (138 kPa).
  - b. Tubing: PE or PVC; 1/8-inch (3-mm) minimum ID.
4. Drip Tubes with Direct-Attached Emitters:
  - a. Tubing: Flexible PE or PVC with plugged end.
  - b. Emitters: Devices to deliver water at approximately 20 psig (138 kPa).
    - 1) Body Material: PE or vinyl, with flow control.
    - 2) Mounting: Inserted into tubing at set intervals.
5. Drip Tubes with Remote Discharge:
  - a. Tubing: Flexible PE or PVC with plugged end.
  - b. Emitters: Devices to deliver water at approximately 20 psig (138 kPa).
    - 1) Body Material: PE or vinyl, with flow control.
    - 2) Mounting: Inserted into tubing at set intervals.
6. Off-Ground Supports: Plastic stakes.
7. Application Pressure Regulators: Brass or plastic housing, NPS 3/4 (DN 20), with corrosion-resistant internal parts; capable of controlling outlet pressure to approximately 20 psig (138 kPa).
8. Filter Units: Brass or plastic housing, with corrosion-resistant internal parts; of size and capacity required for devices downstream from unit.
9. Air Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.
10. Vacuum Relief Valves: Brass or plastic housing, with corrosion-resistant internal parts.

N. Controllers

1. Description:
  - a. Controller Stations for Automatic Control Valves: Each station is variable from approximately 5 to 60 minutes. Include switch for manual or automatic operation of each station.
  - b. Exterior Control Enclosures: NEMA 250, Type 4, weatherproof, with locking cover and two matching keys; include provision for grounding.
    - 1) Body Material: Enameled-steel sheet metal **OR** Stainless-steel sheet metal **OR** Molded plastic, **as directed**.
    - 2) Mounting: Freestanding type for concrete base **OR** Surface type for wall, **as directed**.
  - c. Interior Control Enclosures: NEMA 250, Type 12, dripproof, with locking cover and two matching keys.
    - 1) Body Material: Enameled-steel sheet metal **OR** Stainless-steel sheet metal **OR** Molded plastic, **as directed**.



- 2) Mounting: Freestanding type for concrete base **OR** Surface type for wall, **as directed**.
  - d. Control Transformer: 24-V secondary, with primary fuse.
  - e. Timing Device: Adjustable, 24-hour, 14-day clock, with automatic operations to skip operation any day in timer period, to operate every other day, or to operate two or more times daily.
    - 1) Manual or Semiautomatic Operation: Allows this mode without disturbing preset automatic operation.
    - 2) Nickel-Cadmium Battery and Trickle Charger: Automatically powers timing device during power outages.
    - 3) Surge Protection: Metal-oxide-varistor type on each station and primary power.
  - f. Moisture Sensor: Adjustable from one to seven days, to shut off water flow during rain.
  - g. Wiring: UL 493, Type UF multiconductor, with solid-copper conductors; insulated cable; suitable for direct burial.
    - 1) Feeder-Circuit Cables: No. 12 AWG minimum, between building and controllers.
    - 2) Low-Voltage, Branch-Circuit Cables: No. 14 AWG minimum, between controllers and automatic control valves; color-coded different from feeder-circuit-cable jacket color; with jackets of different colors for multiple-cable installation in same trench.
    - 3) Splicing Materials: Manufacturer's packaged kit consisting of insulating, spring-type connector or crimped joint and epoxy resin moisture seal; suitable for direct burial.
  - h. Concrete Base: Reinforced precast concrete not less than **36 by 24 by 4 inches (900 by 600 by 100 mm)** thick, and **6 inches (150 mm)** greater in each direction than overall dimensions of controller. Include opening for wiring.
- O. Boxes For Automatic Control Valves
1. Plastic Boxes:
    - a. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
      - 1) Size: As required for valves and service.
      - 2) Shape: Round **OR** Square **OR** Rectangular, **as directed**.
      - 3) Sidewall Material: PE **OR** PE, ABS, or FRP, **as directed**.
      - 4) Cover Material: PE **OR** PE, ABS, or FRP, **as directed**.
        - a) Lettering: "VALVE BOX" **OR** "IRRIGATION," **as directed**.
  2. Polymer-Concrete Boxes:
    - a. Description: Box and cover, with open bottom and openings for piping; designed for installing flush with grade.
      - 1) Size: As required for valves and service.
      - 2) Shape: Round **OR** Square **OR** Rectangular, **as directed**.
      - 3) Sidewall Material: Polymer concrete with lateral and vertical sidewall design loading of **5000 lb (2268 kg) OR 10,000 lb (4536 kg) OR 15,000 lb (6800 kg)**, **as directed**, minimum over **10 by 10 inches (254 by 254 mm)** square.
      - 4) Cover Material: Polymer concrete **OR** Reinforced polymer concrete, **as directed**, with cover design loading of **5000 lb (2268 kg) OR 10,000 lb (4536 kg) OR 15,000 lb (6800 kg)**, **as directed**, minimum over **10 by 10 inches (254 by 254 mm)** square.
        - a) Lettering: "VALVE BOX" **OR** "IRRIGATION," **as directed**.
  3. Drainage Backfill: Cleaned gravel or crushed stone, graded from **3/4 inch (19 mm)** minimum to **3 inches (75 mm)** maximum.

### 1.3 EXECUTION

- A. Earthwork
1. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving".
  2. Install warning tape directly above pressure piping, **12 inches (300 mm)** below finished grades, except **6 inches (150 mm)** below subgrade under pavement and slabs.

3. Drain Pockets: Excavate to sizes indicated. Backfill with cleaned gravel or crushed stone, graded from **3/4 to 3 inches (19 to 75 mm)**, to **12 inches (300 mm)** below grade. Cover gravel or crushed stone with sheet of asphalt-saturated felt and backfill remainder with excavated material.
  4. Provide minimum cover over top of underground piping according to the following:
    - a. Irrigation Main Piping: Minimum depth of **36 inches (900 mm)** below finished grade, or not less than **18 inches (450 mm)** below average local frost depth, whichever is deeper.
    - b. Circuit Piping: **12 inches (300 mm)**.
    - c. Drain Piping: **12 inches (300 mm)**
    - d. Sleeves: **24 inches (600 mm)**.
- B. Piping Installation
1. Location and Arrangement: Drawings indicate location and arrangement of piping systems. Install piping as indicated unless deviations are approved on Coordination Drawings.
  2. Install piping at minimum uniform slope of 0.5 percent down toward drain valves.
  3. Install piping free of sags and bends.
  4. Install groups of pipes parallel to each other, spaced to permit valve servicing.
  5. Install fittings for changes in direction and branch connections.
  6. Install unions adjacent to valves and to final connections to other components with **NPS 2 (DN 50)** or smaller pipe connection.
  7. Install flanges adjacent to valves and to final connections to other components with **NPS 2-1/2 (DN 65)** or larger pipe connection.
  8. Install underground thermoplastic piping according to ASTM D 2774 and ASTM F 690.
  9. Install expansion loops in control-valve boxes for plastic piping.
  10. Lay piping on solid subbase, uniformly sloped without humps or depressions.
  11. Install ductile-iron piping according to AWWA C600.
  12. Install PVC piping in dry weather when temperature is above **40 deg F (5 deg C)**. Allow joints to cure at least 24 hours at temperatures above **40 deg F (5 deg C)** before testing.
  13. Install water regulators with shutoff valve and strainer on inlet and pressure gage on outlet. Install shutoff valve on outlet. Install aboveground or in control-valve boxes.
  14. Water Hammer Arresters: Install between connection to building main and circuit valves aboveground or in control-valve boxes.
  15. Install piping in sleeves under parking lots, roadways, and sidewalks.
  16. Install sleeves made of Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe and socket fittings, and solvent-cemented joints.
  17. Install transition fittings for plastic-to-metal pipe connections according to the following:
    - a. Underground Piping:
      - 1) **NPS 1-1/2 (DN 40)** and Smaller: Plastic-to-metal transition fittings.
      - 2) **NPS 2 (DN 50)** and Larger: AWWA transition couplings.
    - b. Aboveground Piping:
      - 1) **NPS 2 (DN 50)** and Smaller: Plastic-to-metal transition fittings **OR** unions, **as directed**.
      - 2) **NPS 2 (DN 50)** and Larger: Use dielectric flange kits with one plastic flange.
  18. Install dielectric fittings for dissimilar-metal pipe connections according to the following:
    - a. Underground Piping:
      - 1) **NPS 2 (DN 50)** and Smaller: Dielectric coupling or dielectric nipple.
      - 2) **NPS 2-1/2 (DN 65)** and Larger: Prohibited except in control-valve box.
    - b. Aboveground Piping:
      - 1) **NPS 2 (DN 50)** and Smaller: Dielectric union.
      - 2) **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Dielectric flange.
      - 3) **NPS 5 (DN 125)** and Larger: Dielectric flange kit.
    - c. Piping in Control-Valve Boxes:
      - 1) **NPS 2 (DN 50)** and Smaller: Dielectric union.
      - 2) **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**: Dielectric flange.
      - 3) **NPS 5 (DN 125)** and Larger: Dielectric flange kit.

C. Joint Construction



1. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
  2. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
  3. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
    - a. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
    - b. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
  4. Flanged Joints: Select rubber gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
  5. Ductile-Iron Piping Gasketed Joints: Comply with AWWA C600 and AWWA M41.
  6. Copper-Tubing Brazed Joints: Construct joints according to CDA's "Copper Tube Handbook," using copper-phosphorus brazing filler metal.
  7. Copper-Tubing Soldered Joints: Apply ASTM B 813 water-flushable flux to tube end unless otherwise indicated. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy (0.20 percent maximum lead content) complying with ASTM B 32.
  8. PE Piping Fastener Joints: Join with insert fittings and bands or fasteners according to piping manufacturer's written instructions.
  9. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
    - a. Plain-End PE Pipe and Fittings: Use butt fusion.
    - b. Plain-End PE Pipe and Socket Fittings: Use socket fusion.
  10. PVC Piping Solvent-Cemented Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
    - a. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
    - b. PVC Pressure Piping: Join schedule number, ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
    - c. PVC Nonpressure Piping: Join according to ASTM D 2855.
- D. Valve Installation
1. Underground Curb Valves: Install in curb-valve casings with tops flush with grade.
  2. Underground Iron Gate Valves, Resilient Seat: Comply with AWWA C600 and AWWA M44. Install in valve casing with top flush with grade.
    - a. Install valves and PVC pipe with restrained, gasketed joints.
  3. Aboveground Valves: Install as components of connected piping system.
  4. Pressure-Reducing Valves: Install in boxes for automatic control valves or aboveground between shutoff valves. Install full-size valved bypass, **as directed**.
  5. Throttling Valves: Install in underground piping in boxes for automatic control valves.
  6. Drain Valves: Install in underground piping in boxes for automatic control valves.
- E. Sprinkler Installation
1. Install sprinklers after hydrostatic test is completed.
  2. Install sprinklers at manufacturer's recommended heights.
  3. Locate part-circle sprinklers to maintain a minimum distance of **4 inches (100 mm)** from walls and **2 inches (50 mm)** from other boundaries unless otherwise indicated.
- F. Drip Irrigation Specialty Installation
1. Install freestanding emitters on pipe riser to mounting height indicated.
  2. Install manifold emitter systems with tubing to emitters. Plug unused manifold outlets. Install emitters on off-ground supports at height indicated.

3. Install multiple-outlet emitter systems with tubing to outlets. Plug unused emitter outlets. Install outlets on off-ground supports at height indicated.
  4. Install drip tubes with direct-attached emitters on ground.
  5. Install drip tubes with remote-discharge on ground with outlets on off-ground supports at height indicated.
  6. Install off-ground supports of length required for indicated mounted height of device.
  7. Install application pressure regulators and filter units in piping near device being protected, and aboveground **OR** in control-valve boxes, **as directed**.
  8. Install air relief valves and vacuum relief valves in piping, and aboveground **OR** in control-valve boxes, **as directed**.
- G. Automatic Irrigation-Control System Installation
1. Equipment Mounting: Install interior controllers on floor **OR** concrete bases **OR** wall, **as directed**.
    - a. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    - b. Install anchor bolts to elevations required for proper attachment to supported equipment.
  2. Equipment Mounting: Install exterior freestanding controllers on precast concrete bases.
    - a. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
    - b. Install anchor bolts to elevations required for proper attachment to supported equipment.
  3. Install control cable in same trench as irrigation piping and at least **2 inches (51 mm)** below or beside piping. Provide conductors of size not smaller than recommended by controller manufacturer. Install cable in separate sleeve under paved areas.
- H. Connections
1. Comply with requirements for piping specified in Division 22 Section "Facility Water Distribution Piping" for water supply from exterior water service piping, water meters, protective enclosures, and backflow preventers. Drawings indicate general arrangement of piping, fittings, and specialties.
  2. Install piping adjacent to equipment, valves, and devices to allow service and maintenance.
  3. Connect wiring between controllers and automatic control valves.
- I. Identification
1. Identify system components. Comply with requirements for identification specified in Division 22 Section "Identification For Plumbing Piping And Equipment".
  2. Equipment Nameplates and Signs: Install engraved plastic-laminate equipment nameplates and signs on each automatic controller.
    - a. Text: In addition to identifying unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
  3. Warning Tapes: Arrange for installation of continuous, underground, detectable warning tapes over underground piping during backfilling of trenches. See Division 31 Section "Earth Moving" for warning tapes.
- J. Field Quality Control
1. Perform tests and inspections.
  2. Tests and Inspections:
    - a. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
    - b. Operational Test: After electrical circuitry has been energized, operate controllers and automatic control valves to confirm proper system operation.
    - c. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
  3. Any irrigation product will be considered defective if it does not pass tests and inspections.
  4. Prepare test and inspection reports.

- K. Adjusting
1. Adjust settings of controllers.
  2. Adjust automatic control valves to provide flow rate at rated operating pressure required for each sprinkler circuit.
  3. Adjust sprinklers and devices, except those intended to be mounted aboveground, so they will be flush with, or not more than **1/2 inch (13 mm)** above, finish grade.
- L. Cleaning
1. Flush dirt and debris from piping before installing sprinklers and other devices.
- M. Piping Schedule
1. Install components having pressure rating equal to or greater than system operating pressure.
  2. Piping in control-valve boxes and aboveground may be joined with flanges or unions instead of joints indicated.
  3. Aboveground irrigation main piping, **NPS 4 (DN 100)** and smaller, shall be one of the following:
    - a. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
    - b. **Type L (Type B) OR Type M (Type C), as directed**, hard copper tube, wrought- or cast-copper fittings, and brazed **OR** soldered, **as directed**, joints.
    - c. Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe; socket-type PVC fittings; and solvent-cemented joints.
    - d. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
  4. Aboveground irrigation main piping, **NPS 5 (DN 125)** and larger, shall be one of the following:
    - a. Galvanized-steel pipe and galvanized-steel pipe nipples; galvanized, gray-iron threaded fittings; and threaded joints.
    - b. Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe and socket fittings; and solvent-cemented joints.
    - c. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
  5. Underground irrigation main piping, **NPS 4 (DN 100)** and smaller, shall be one of the following:
    - a. **NPS 3 and NPS 4 (DN 80 and DN 100)** ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
    - b. **NPS 3 and NPS 4 (DN 80 and DN 100)** ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
    - c. **Type L (Type B)** soft copper tube, wrought-copper fittings, and brazed joints.
    - d. **NPS 4 (DN 100)** PE pressure pipe; PE butt, heat-fusion or socket-type fittings; and heat-fusion joints.
    - e. Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe and socket fittings, and solvent-cemented joints.
    - f. Schedule 80, PVC pipe; Schedule 80, threaded PVC fittings; and threaded joints.
    - g. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.
  6. Underground irrigation main piping, **NPS 5 (DN 125)** and larger, shall be one of the following:
    - a. **NPS 6 (DN 150)** and larger ductile-iron, mechanical-joint pipe; ductile-iron, mechanical-joint fittings, glands, bolts, and nuts; and gasketed joints.
    - b. **NPS 6 (DN 150)** and larger ductile-iron, push-on-joint pipe; ductile-iron, push-on-joint fittings and gaskets; and gasketed joints.
    - c. PE pressure pipe; PE butt, heat-fusion fittings; and heat-fusion joints.
    - d. Schedule 40 **OR** Schedule 80, **as directed**, PVC pipe and socket fittings; and solvent-cemented joints.
    - e. SDR 21, PVC, pressure-rated pipe; Schedule 80, PVC socket fittings; and solvent-cemented joints.
  7. Circuit piping, **NPS 2 (DN 50)** and smaller, shall be one of the following:
    - a. **SIDR 7 OR SIDR 9, as directed**, PE, controlled ID pipe; insert fittings for PE pipe; and fastener joints.

- b. DR 9 **OR** DR 11, **as directed**, PE, controlled OD pipe; PE butt, heat-fusion, or PE socket-type fittings; and heat-fusion joints.
    - c. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
    - d. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
  8. Circuit piping, **NPS 2-1/2 to NPS 4 (DN 65 to DN 100)**, shall be one of the following:
    - a. SDR 7 **OR** SDR 9, **as directed**, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
    - b. DR 9 **OR** DR 11, **as directed**, PE, controlled OD pipe; PE socket or butt-fusion fittings; and heat-fusion joints. **NPS 3 (DN 80)** pipe and fittings if **NPS 2-1/2 (DN 65)** pipe and fittings are not available.
    - c. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
    - d. SDR 26, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
  9. Underground Branches and Offsets at Sprinklers and Devices: Schedule 80, PVC pipe; threaded PVC fittings; and threaded joints.
    - a. Option: Plastic swing-joint assemblies, with offsets for flexible joints, manufactured for this application.
  10. Risers to Aboveground Sprinklers and Specialties: **Type L (Type B) OR Type M (Type C), as directed**, hard copper tube, wrought-copper fittings, and brazed **OR** soldered, **as directed**, joints.
  11. Risers to Aboveground Sprinklers and Specialties: Schedule 80, PVC pipe and socket fittings; and solvent-cemented joints.
  12. Drain piping shall be one of the following:
    - a. SDR 9, 11.5, or 15, PE, controlled ID pipe; insert fittings for PE pipe; and banded or fastener joints.
    - b. Schedule 40, PVC pipe and socket fittings; and solvent-cemented joints.
    - c. SDR 21, 26, or 32.5, PVC, pressure-rated pipe; Schedule 40, PVC socket fittings; and solvent-cemented joints.
- N. Valve Schedule
1. Underground, Shutoff-Duty Valves: Use the following:
    - a. **NPS 2 (DN 50)** and Smaller: Curb valve, curb-valve casing, and shutoff rod.
    - b. **NPS 3 (DN 80)** and Larger: Iron gate valve, resilient seated; iron gate valve casing; and operating wrench(es).
  2. Aboveground, Shutoff-Duty Valves:
    - a. **NPS 2 (DN 50)** and Smaller: Brass **OR** Bronze **OR** Plastic, **as directed**, ball valve.
    - b. **NPS 2 (DN 50)** and Smaller: Bronze gate valve.
    - c. **NPS 2-1/2 (DN 65)** and Larger: Iron ball valve.
    - d. **NPS 2-1/2 (DN 65)** and Larger: Iron gate valve, NRS **OR** OS&Y, **as directed**.
  3. Throttling-Duty Valves:
    - a. **NPS 2 (DN 50)** and Smaller: Bronze **OR** Plastic, **as directed**, automatic control valve.
    - b. **NPS 2 (DN 50)** and Smaller: Brass **OR** Bronze **OR** Plastic, **as directed**, ball valve.
    - c. **NPS 2-1/2 and NPS 3 (DN 65 and DN 80)**: Bronze **OR** Plastic, **as directed**, automatic control valve.
    - d. **NPS 2-1/2 and NPS 3 (DN 65 and DN 80)**: Iron ball valve.
  4. Drain Valves:
    - a. **NPS 1/2 and NPS 3/4 (DN 15 and DN 20)**: Automatic drain valve.
    - b. **NPS 1/2 and NPS 3/4 (DN 15 and DN 20)**: Brass **OR** Bronze **OR** Plastic, **as directed**, ball valve.
    - c. **NPS 1/2 and NPS 3/4 (DN 15 and DN 20)**: Bronze gate valve.
    - d. **NPS 1 to NPS 2 (DN 25 to DN 50)**: Brass **OR** Bronze **OR** Plastic, **as directed**, ball valve.
    - e. **NPS 1 to NPS 2 (DN 25 to DN 50)**: Bronze gate valve.

END OF SECTION 32 84 13 00

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Task	Specification	Specification Description
32 84 13 00	07 21 13 13	Modified Bitumous Protected Membrane Roofing
32 84 23 00	01 22 16 00	No Specification Required
32 84 23 00	32 84 13 00	Irrigation Systems
32 84 23 00	03 05 13 00	Cast-In-Place Concrete
32 84 23 00	07 21 13 13	Modified Bitumous Protected Membrane Roofing
32 84 23 00	07 63 00 00	Common Work Results for Fire Suppression
32 84 23 00	07 63 00 00a	Common Work Results for Plumbing
32 84 23 00	07 63 00 00b	Common Work Results for HVAC

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## SECTION 32 91 13 16 - TREE RELOCATION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers labor, materials, necessary equipment and services to complete the tree relocation work. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.
2. Before tree excavation, pruning, removal, or relocation of existing trees, contractor shall notify:
  - a. the Owner of schedule of operation.
  - b. Appropriate utility companies and the Owner for flagging and coordination of service disconnection as necessary to complete work.
  - c. Coordinate work with other trades.

#### B. Definitions

1. Toxic Substances: Do not deliver any toxic substance or item as defined by the state, to the site without furnishing to the Owner a Material Safety Data Sheet (MSDS). Provide current MSDS information with each initial shipment.
  - a. The MSDS shall contain the following information:
    - 1) The chemical name and the common name of the toxic substance.
    - 2) The hazards or other risks in the use of the toxic substance, including:
      - a) The potential for fire, explosion, corrosivity and reactivity.
      - b) The known acute and chronic health effects of risks from exposure, including the medical conditions which are generally recognized as being aggravated by exposure to the toxic substance.
      - c) The primary routes of entry and symptoms of overexposure.
    - 3) The proper precautions, handling practices, necessary personal protective equipment, any other safety precautions in the use of or exposure to the toxic substance including appropriate emergency treatment in case of overexposure.
    - 4) The emergency procedure for spills, fire disposal, and first aid.
    - 5) A description in lay terms of the known specific potential health risks posed by the toxic substance intended to alert any person reading this information.
    - 6) The year and month, if available, that the information was compiled and the name, address, and emergency telephone number of the manufacturer responsible for preparing the information.

#### C. Description

1. Protect existing trees to remain during construction phases. Provide tree protection barriers for those existing trees adjacent to tree transplantation operations. Any trees scarred or destroyed, designated to remain, will be replaced at the Contractor's expense, with similar species, size, and quality.
2. Remove other vegetation as necessary and as required to meet project requirements to accommodate new plantings. Prepare areas to be planted according to Division 32 Section "Plants".
3. Resulting tree pits of relocated material shall be backfilled with clean fill and brought back flush with surrounding grade, unless the pits are to be immediately replanted. Stabilize grade if required. Correct problems caused by erosion, wind, etc., in the reclaimed area. Pits to be quickly replanted shall be surrounded by safety barricades to prevent accidental falls into pits.
  - a. In areas where new plant material will replace relocated plant material, appropriate planting soil mix shall be used as backfill.

#### D. Submittals





1. Submit a list of equipment, procedure, and labor force anticipated for use for tree relocation for approval by the Owner.
2. Submit a schedule by day indicating units to be dug and relocated. Note materials requiring root pruning, and that the relocation schedule is to begin at the end of the specified root pruning period.
3. Obtain permits required by authority having jurisdiction.
4. Submit written certification that trees indicated to remain have been protected during the course of construction according to recognized standards of the industry. Certify that where damage did occur:
  - a. Trees were promptly and properly treated.
  - b. Indicate which damaged trees (if any) are incapable of retaining full growth potential and are recommended to be replaced.
5. Submit for approval, proposed methods, and schedule for effecting tree and plant protection.

E. Quality Assurance

1. Unless otherwise specified, tree transplanting shall comply with NAA Ref. 1.
2. Comply with NAA standards for pruning and remove branches from trees to remain to clear new construction.
3. Recommend procedures to compensate for loss of roots (if any) and perform initial pruning of branches and stimulation of root growth where removed to accommodate new construction.
4. Perform tree repair work for damage incurred by new construction.
5. Provide routine progress evaluation reports on relocated trees until the end of the maintenance period.
6. Evaluate existing trees and verify trees are free of disease and ready to survive relocation from the site to their new location on-site or off-site.

F. Delivery, Storage, and Handling

1. Properly handle trees and palms during moving so trunks will not be scarred or damaged and to avoid broken limbs. Broken limbs not causing the tree to be rejected shall be repaired as follows:
  - a. Properly prune dead, dying, or damaged branches with clean, sharp equipment.
  - b. Remove injured bark and wood of a tree would with a clean, sharp knife to a point where healthy bark and wood make contact at their margins.
  - c. Inspect and treat wound for insect and disease.
  - d. Seal wounds with bituminous base wound paint for all oak limbs greater than 3 inch diameter.
2. Transport trees on vehicles of adequate size to prevent overcrowding, broken limbs, foliage damage, or root ball damage.
3. Keep root balls moist during relocation.
4. Protect tree crowns with shade cloth to prevent desiccation and wind burn. Crowns shall be periodically sprayed with water to help ensure against desiccation.
5. Handle plant material only in ways and means accepted by the landscaping industry and accepted by the Owner.
6. Plant material shall be planted the same day it is dug. Coordinate preparation of planting pits or beds to ensure this schedule.

G. Warranty

1. Relocated plant material does not fall under the standard 12 month guarantee.
2. For relocated trees or palms that die, replace their canopy area with new trees as specified.
  - a. Canopy spread for all palms and trees shall be listed on proposal when submitted for relocation work.
  - b. Replacements (mitigation plantings) shall be provided at no additional cost to the Owner.
  - c. Submit the attached form to the Owner for review and approval.
  - d. Proposed replacement canopy tree species shall be the Owner accepted trees and palms.
3. Repair damage to other plants and lawn or construction work within the relocation area during tree transplantation at no cost to the Owner. This includes, but is not limited to, damage to curbs,

walks, roads, fences, site furnishings, etc. Replacing and replanting of damaged trees or shrubs shall be according to Division 32 Section "Plants" Replacing and replanting of damaged turf shall be according to Division 32 Section "Turf And Grasses".

H. Maintenance

1. Maintain relocated plant materials immediately after each item is planted and continued until the 90 day watering period is completed, upon which time the Owner will take over maintenance of materials following procedures and recommendations of contractor and specifications.
2. During the maintenance period, maintain relocated plant materials.

1.2 PRODUCT

A. Materials

1. Bone meal shall be readily available steamed bone meal, useable as a natural organic nitrogen fertilizer.
2. Peat moss, topsoil, planting soil, mulch, staking, and guying shall be as specified in Division 32 Section "Plants".

1.3 EXECUTION

A. Transplantation

1. Transplanting shall consist of on-site or off-site transplanting of existing trees or palms from proposed construction areas to permanent positions.
2. Digging, Wrapping, and Handling: Plants shall be dug and prepared for moving in a manner that will not cause damage to branches, shape, root system, and development.
3. Balled and Burlapped Plants:
  - a. Balls shall be firmly wrapped with burlap or accepted cloth substitute.
  - b. No balled plant will be acceptable if the ball is cracked and broken or if the stem or trunk is loose in the ball, either before or during transplanting.
  - c. Balled plants shall be lifted and handled from the bottom of the ball.
  - d. Protect ball and deliver to the site, plant immediately, and water thoroughly.
  - e. Ball sizes shall be as recommended in ANSI Z 60.1.

B. Planting

1. Relocated Material
  - a. Relocated trees/palms shall be planted according to procedures described for new material, Division 32 Section "Plants". Verify final grades have been established before planting operations. Ensure proposed planting pits drain by test-filling with water before transplantation.
  - b. Continue watering and caring for relocated material as specified.
  - c. Mulch tree pit areas to reduce weeds, discourage foot traffic, conserve moisture, and minimize temperature fluctuations.
  - d. Brace trunk and leave in place for approximately one year until trees are wind firm.
  - e. Wrap trunks and structural branches of thin-barked trees to protect against sun scald and dehydration. Retain through at least one growing season, and through cold season.
  - f. Feed with a diluted solution of N-P-K in solution form with a soil needle, providing water, air, and nutrients.
  - g. Where foliage is retarded, spray with one of the soluble types of foliage feeders.
  - h. At time of planting, fill air pockets and keep roots, especially feeder roots, moist, live, and healthy. Use soil needles for watering new transplants. Direct fine spray at foliage to help harden-off new leaves.

- C. Staking And Guying: Stake and guy designated material according to procedures described for new plant materials, Division 32 Section "Plants".

**D. Watering**

1. Following transplantation, water trees daily for the first two weeks, every other day for the next three weeks, and every third day for the balance of the three month watering/maintenance period. Such watering shall thoroughly saturate the root ball to its full depth.
2. Following relocation, trees designated for transplanting shall be watered as specified in this section. Such watering shall thoroughly saturate the root ball to its full depth.
3. Provide manual watering of relocated plant materials for 90 days. If used, after watering period, Contractor shall be responsible for the complete removal of all temporary watering systems.

**E. Tagging:** Trees within the designated areas for relocation shall be clearly marked by means of yellow plastic surveyor's ribbons and coordinated with, inspected, and accepted by the Owner before root pruning and digging.**F. Root Preparation**

1. Trees to be relocated shall be root pruned at least 45 days before digging with clean, sharp equipment.
  - a. Maintain root pruned materials by watering, weeding, mowing, spraying, fertilizing, and other horticulture practices.
  - b. After root pruning, backfill with good rooting medium, fertilize with organic fertilizer to promote root growth.
  - c. Mulch to reduce weeds, discourage foot traffic, conserve moisture, and minimize temperature fluctuation.
2. Root Ball Size Chart: Root ball sizes shall be according to minimum standards set forth in Grades and Standards for Nursery Plants Part II, Palms and Trees, local state Department of Agriculture.
  - a. Trees-Minimum Ball Sizes:

Caliper	Minimum Ball Diameter
---------	-----------------------

3-1/2" to 4"	28"
--------------	-----

4" to 4-1/2"	30"
--------------	-----

4-1/2" to 5"	32"
--------------	-----

5" to 5-1/2"	34"
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Larger sizes increase proportionally.

- b. Minimum Ball Depth:

Ball Diameter	Depth
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Less than 20"	Not less than 75 percent of diameter.
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20" to 30"	Not less than 65 percent of diameter.
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30" to 48"	Not less than 60 percent of diameter.
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**G. Crown Preparation**

1. Shade and Flowering Trees
  - a. Shade Trees: Selectively prune and thin crown to remove approximately one third of the branches. Preserve the basic shape and form of the tree, eliminate cross-branching and dead or diseased branches.
  - b. Hand strip selected species of all leaves following pruning and before moving.
2. Palms: Follow standard procedure for transplantation of palms.

**H. Hand Digging:** Burlapping is required. Trees that are burlapped for relocation shall comply and be handled in same manner as new plant material specified in Section "Exterior Plants."

- I. Special Conditions
  - 1. Multi-Trunk Trees: Relocate multi-trunk tree as one unit. Measure unit by taking the aggregate total of all DBH measurements.
  - 2. Multi-Trunk Palms: Relocate multi-trunk palms as one unit. Unit shall be measured as follows:
    - a. 50 percent of the value in dollars of the largest trunk in the grouping times the number of trunks in the clump.
  - 3. On-site relocation
    - a. On-site relocation shall include root pruning, canopy pruning, on-site transportation, hauling and dumping of debris, and 90-day maintenance.
    - b. If the tree or palm should die within the 90-day maintenance period, remove the tree, replace the material, and restore the site at no additional cost to the Owner.
- J. Cleaning
  - 1. Cleaning up the Site
    - a. Upon completion of the work, thoroughly clean up the project site.
    - b. In addition to removing equipment, unused materials, deleterious material, and surplus excavated material, the Contractor shall fine grade all disturbed areas and the areas adjacent to the transplanted material to provide a neat and uniform site.
    - c. All damaged or altered existing structures, as a result of the landscape work, shall be corrected.

END OF SECTION 32 91 13 16

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Task	Specification	Specification Description
32 91 13 26	32 91 13 16	Tree Relocation

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## SECTION 32 91 13 33 - LAWNS AND GRASSES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for lawns and grasses. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Seeding.
  - b. Hydroseeding.
  - c. Sodding.
  - d. Plugging.
  - e. Sprigging.
  - f. Meadow grasses and wildflowers.
  - g. Turf renovation.
  - h. Erosion-control material(s).
  - i. Grass paving.

#### C. Definitions

1. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
2. Finish Grade: Elevation of finished surface of planting soil.
3. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
4. Pesticide: A substance or mixture intended for preventing, destroying, repelling, or mitigating a pest. This includes insecticides, miticides, herbicides, fungicides, rodenticides, and molluscicides. It also includes substances or mixtures intended for use as a plant regulator, defoliant, or desiccant.
5. Pests: Living organisms that occur where they are not desired or that cause damage to plants, animals, or people. These include insects, mites, grubs, mollusks (snails and slugs), rodents (gophers, moles, and mice), unwanted plants (weeds), fungi, bacteria, and viruses.
6. Planting Soil: Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
7. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
8. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
9. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Certification of Grass Seed.
  - a. Certification of each seed mixture for turfgrass sod **OR** plugs, **as directed**.
3. Product Certificates: For soil amendments and fertilizers, from manufacturer.
4. Maintenance Instructions: Recommended procedures to be established by the Owner for maintenance of turf and meadows during a calendar year. Submit before expiration of required initial maintenance periods.





E. Quality Assurance

1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
  - a. Pesticide Applicator: State licensed, commercial.
2. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory.
  - a. The soil-testing laboratory shall oversee soil sampling.
  - b. Report suitability of tested soil for turf growth.
    - 1) State recommendations for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
    - 2) Report presence of problem salts, minerals, or heavy metals; if present, provide additional recommendations for corrective action.

F. Delivery, Storage, And Handling

1. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.
2. Sod: Harvest, deliver, store, and handle sod according to requirements in "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in TPI's "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.
3. Bulk Materials:
  - a. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
  - b. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
  - c. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.

G. Maintenance Service

1. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 1.3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
  - a. Seeded Turf: 60 days from date of planting completion **OR** Final Completion, **as directed**.
    - 1) When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.
  - b. Sodded Turf: 30 days from date of planting completion **OR** Final Completion, **as directed**.
  - c. Plugged Turf: 30 days from date of planting completion **OR** Final Completion, **as directed**.
  - d. Sprigged Turf: 30 days from date of planting completion **OR** Final Completion, **as directed**.
2. Initial Meadow Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 1.3. Begin maintenance immediately after each area is planted and continue until acceptable meadow is established, but for not less than 40 days from date of planting completion **OR** Final Completion, **as directed**.
3. Continuing Maintenance Proposal: From Installer to the Owner, in the form of a standard yearly (or other period) maintenance agreement, starting on date initial maintenance service is concluded. State services, obligations, conditions, and terms for agreement period and for future renewal options.

## 1.2 PRODUCTS

### A. Seed

1. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
2. Seed Species: If grass seed is required to be certified by the State Department of Agriculture, State-certified seed of grass species as follows:  
**OR**  
Seed Species: If grass seed is not required to be certified by the State Department of Agriculture, seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
  - a. Warm-season grass
    - 1) Full Sun: Bermudagrass (*Cynodon dactylon*).
  - b. Cool-season grass
    - 1) Full Sun: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.
    - 2) Sun and Partial Shade: Proportioned by weight as follows:
      - a) 50 percent Kentucky bluegrass (*Poa pratensis*).
      - b) 30 percent chewings red fescue (*Festuca rubra* variety).
      - c) 10 percent perennial ryegrass (*Lolium perenne*).
      - d) 10 percent redtop (*Agrostis alba*).
    - 3) Shade: Proportioned by weight as follows:
      - a) 50 percent chewings red fescue (*Festuca rubra* variety).
      - b) 35 percent rough bluegrass (*Poa trivialis*).
      - c) 15 percent redtop (*Agrostis alba*).
3. Grass Seed Mix: Proprietary seed mix as directed by the Owner.

### B. Turfgrass Sod

1. Turfgrass Sod: Certified **OR** Approved **OR** Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, **as directed**, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, strongly rooted, and capable of vigorous growth and development when planted.
2. Turfgrass Species (warm-season grass): Bermudagrass (*Cynodon dactylon*) **OR** Carpetgrass (*Axonopus affinis*) **OR** Centipedegrass (*Eremochloa ophiuroides*) **OR** St. Augustinegrass (*Stenotaphrum secundatum*) **OR** Zoysiagrass (*Zoysia japonica*) **OR** Zoysiagrass (*Zoysia matrella*), **as directed**.
3. Turfgrass Species (cool-season grass): Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
  - a. Full Sun: Kentucky bluegrass (*Poa pratensis*), a minimum of three cultivars.
  - b. Sun and Partial Shade: Proportioned by weight as follows:
    - 1) 50 percent Kentucky bluegrass (*Poa pratensis*).
    - 2) 30 percent chewings red fescue (*Festuca rubra* variety).
    - 3) 10 percent perennial ryegrass (*Lolium perenne*).
    - 4) 10 percent redtop (*Agrostis alba*).
  - c. Shade: Proportioned by weight as follows:
    - 1) 50 percent chewings red fescue (*Festuca rubra* variety).
    - 2) 35 percent rough bluegrass (*Poa trivialis*).
    - 3) 15 percent redtop (*Agrostis alba*).

### C. Plugs

1. Plugs: Turfgrass sod, certified **OR** approved **OR** Number 1 Quality/Premium, including limitations on thatch, weeds, diseases, nematodes, and insects, **as directed**, complying with "Specifications for Turfgrass Sod Materials" in TPI's "Guideline Specifications to Turfgrass Sodding." Furnish viable sod of uniform density, color, and texture, cut into square or round plugs, strongly rooted,



and capable of vigorous growth and development when planted; of the following turfgrass species and plug size:

- a. Turfgrass Species (warm-season grass): Bermudagrass (*Cynodon dactylon*) **OR** Carpetgrass (*Axonopus affinis*) **OR** Centipedegrass (*Eremochloa ophiuroides*) **OR** St. Augustinegrass (*Stenotaphrum secundatum*) **OR** Zoysiagrass (*Zoysia japonica*) **OR** Zoysiagrass (*Zoysia matrella*), **as directed**.
- b. Plug Size: **2 inches (50 mm) OR 3 inches (75 mm) OR 4 inches (100 mm), as directed.**

D. Sprigs

1. Sod Sprigs: Healthy living stems, rhizomes, or stolons with a minimum of two nodes and attached roots free of soil, of the following turfgrass species:
  - a. Turfgrass Species (warm-season grass): Bermudagrass (*Cynodon dactylon*) **OR** Carpetgrass (*Axonopus affinis*) **OR** Centipedegrass (*Eremochloa ophiuroides*) **OR** St. Augustinegrass (*Stenotaphrum secundatum*) **OR** Zoysiagrass (*Zoysia japonica*) **OR** Zoysiagrass (*Zoysia matrella*), **as directed**.
  - b. Turfgrass Species (cool-season grass): Creeping bentgrass (*Agrostis palustris*).

E. Meadow Grasses And Wildflowers

1. Wildflower Seed: Fresh, clean, and dry new seed, of mixed species as directed.
2. Native Grass Seed: Fresh, clean, and dry new seed, of mixed species as directed.
3. Wildflower and Native Grass Seed: Fresh, clean, and dry new seed, of mixed species as directed.
4. Seed Carrier: Inert material, sharp clean sand or perlite, mixed with seed at a ratio of not less than two parts seed carrier to one part seed.

F. Inorganic Soil Amendments

1. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
  - a. Class T, with a minimum of 99 percent passing through **No. 8 (2.36-mm)** sieve and a minimum of 75 percent passing through **No. 60 (0.25-mm)** sieve.  
**OR**  
Class O, with a minimum of 95 percent passing through **No. 8 (2.36-mm)** sieve and a minimum of 55 percent passing through **No. 60 (0.25-mm)** sieve.
  - b. Provide lime in form of ground dolomitic limestone **OR** calcitic limestone **OR** mollusk shells, **as directed**.
2. Sulfur: Granular, biodegradable, containing a minimum of 90 percent sulfur, and with a minimum of 99 percent passing through **No. 6 (3.35-mm)** sieve and a maximum of 10 percent passing through **No. 40 (0.425-mm)** sieve.
3. Iron Sulfate: Granulated ferrous sulfate containing a minimum of 20 percent iron and 10 percent sulfur.
4. Aluminum Sulfate: Commercial grade, unadulterated.
5. Perlite: Horticultural perlite, soil amendment grade.
6. Agricultural Gypsum: Minimum 90 percent calcium sulfate, finely ground with 90 percent passing through **No. 50 (0.30-mm)** sieve.
7. Sand: Clean, washed, natural or manufactured, and free of toxic materials.
8. Diatomaceous Earth: Calcined, 90 percent silica, with approximately 140 percent water absorption capacity by weight.  
**OR**  
Zeolites: Mineral clinoptilolite with at least 60 percent water absorption by weight.

G. Organic Soil Amendments

1. Compost: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through **1-inch (25-mm) OR 3/4-inch (19-mm) OR 1/2-inch (12.5-mm), as directed**, sieve; soluble salt content of 5 to 10

decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:

- a. Organic Matter Content: 50 to 60 percent of dry weight.
- b. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
2. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture, with a pH range of 3.4 to 4.8.
3. Muck Peat: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
4. Wood Derivatives: Decomposed, nitrogen-treated sawdust, ground bark, or wood waste; of uniform texture and free of chips, stones, sticks, soil, or toxic materials.
  - a. In lieu of decomposed wood derivatives, mix partially decomposed wood derivatives with ammonium nitrate at a minimum rate of 0.15 lb/cu. ft. (2.4 kg/cu. m) of loose sawdust or ground bark, or with ammonium sulfate at a minimum rate of 0.25 lb/cu. ft. (4 kg/cu. m) of loose sawdust or ground bark.
5. Manure: Well-rotted, unleached, stable or cattle manure containing not more than 25 percent by volume of straw, sawdust, or other bedding materials; free of toxic substances, stones, sticks, soil, weed seed, and material harmful to plant growth.

#### H. Fertilizers

1. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 1 **OR** 4, **as directed**, percent nitrogen and 10 **OR** 20, **as directed**, percent phosphoric acid.
2. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
3. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
  - a. Composition: 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) of actual nitrogen, 4 percent phosphorous, and 2 percent potassium, by weight.
  - b. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.
4. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
  - a. Composition: 20 percent nitrogen, 10 percent phosphorous, and 10 percent potassium, by weight.  
**OR**  
Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing laboratory.

#### I. Planting Soils

1. Planting Soil: ASTM D 5268 topsoil, with pH range of 5.5 to 7, a minimum of 2 percent organic material content **OR** Existing, native surface topsoil formed under natural conditions with the duff layer retained during excavation process **OR** Existing, in-place surface soil **OR** Imported topsoil or manufactured topsoil from off-site sources; do not obtain from agricultural land, bogs or marshes, **as directed**. Verify suitability of soil to produce viable planting soil. Clean soil of roots, plants, sod, stones, clods, clay lumps, pockets of coarse sand, concrete slurry, concrete layers or chunks, cement, plaster, building debris, and other extraneous materials harmful to plant growth. Mix soil with the following soil amendments and fertilizers in the following quantities to produce planting soil:
  - a. Ratio of Loose Compost to Topsoil by Volume: 1:4 **OR** 1:3 **OR** 1:2, **as directed**.
  - b. Ratio of Loose Sphagnum **OR** Muck, **as directed**, Peat to Topsoil by Volume: as directed by the Owner .
  - c. Ratio of Loose Wood Derivatives to Topsoil by Volume: as directed by the Owner.
  - d. Weight of Lime per 1000 Sq. Ft. (92.9 Sq. m): as directed by the Owner.



- e. Weight of Sulfur **OR** Iron Sulfate **OR** Aluminum Sulfate, **as directed**, per **1000 Sq. Ft. (92.9 Sq. m)**: as directed by the Owner.
- f. Weight of Agricultural Gypsum per **1000 Sq. Ft. (92.9 Sq. m)**: as directed by the Owner.
- g. Volume of Sand Plus 10 Percent Diatomaceous Earth **OR** Zeolites, **as directed**, per **1000 Sq. Ft. (92.9 Sq. m)**: as directed by the Owner.
- h. Weight of Bonemeal per **1000 Sq. Ft. (92.9 Sq. m)**: as directed by the Owner.
- i. Weight of Superphosphate per **1000 Sq. Ft. (92.9 Sq. m)**: as directed by the Owner.
- j. Weight of Commercial Fertilizer per **1000 Sq. Ft. (92.9 Sq. m)**: as directed by the Owner.
- k. Weight of Slow-Release Fertilizer per **1000 Sq. Ft. (92.9 Sq. m)**: as directed by the Owner.

#### J. Mulches

- 1. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- 2. Sphagnum Peat Mulch: Partially decomposed sphagnum peat moss, finely divided or of granular texture, and with a pH range of 3.4 to 4.8.
- 3. Muck Peat Mulch: Partially decomposed moss peat, native peat, or reed-sedge peat, finely divided or of granular texture, with a pH range of 6 to 7.5, and having a water-absorbing capacity of 1100 to 2000 percent.
- 4. Compost Mulch: Well-composted, stable, and weed-free organic matter, pH range of 5.5 to 8; moisture content 35 to 55 percent by weight; 100 percent passing through **1-inch (25-mm)** sieve; soluble salt content of 2 to 5 decisiemens/m; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
  - a. Organic Matter Content: 50 to 60 percent of dry weight.
  - b. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- 5. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- 6. Nonasphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.
- 7. Asphalt Emulsion: ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

#### K. Pesticides

- 1. General: Pesticide, registered and approved by EPA, acceptable to authorities having jurisdiction, and of type recommended by manufacturer for each specific problem and as required for Project conditions and application. Do not use restricted pesticides unless authorized in writing by authorities having jurisdiction.
- 2. Pre-Emergent Herbicide (Selective and Non-Selective): Effective for controlling the germination or growth of weeds within planted areas at the soil level directly below the mulch layer.
- 3. Post-Emergent Herbicide (Selective and Non-Selective): Effective for controlling weed growth that has already germinated.

#### L. Erosion-Control Materials

- 1. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, **6 inches (150 mm)** long.
- 2. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of **0.92 lb/sq. yd. (0.5 kg/sq. m)**, with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, **6 inches (150 mm)** long.
- 3. Erosion-Control Mats: Cellular, non-biodegradable slope-stabilization mats designed to isolate and contain small areas of soil over steeply sloped surface, of **3-inch (75-mm) OR 4-inch (100-mm) OR 6-inch (150-mm)**, **as directed**, nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.

M. Grass-Paving Materials

1. Grass Paving: Cellular, non-biodegradable plastic mats, designed to contain small areas of soil and enhance the ability of turf to support vehicular and pedestrian traffic, of **1-inch (25-mm) OR 1-3/4-inch (45-mm) OR 2-inch (50-mm) OR** manufacturer's standard, **as directed**, nominal mat thickness. Include manufacturer's recommended anchorage system for slope conditions.
2. Base Course: Sound crushed stone or gravel complying with ASTM D 448 for Size No. 8 **OR** Division 31 Section "Earth Moving" for base-course material, **as directed**.
3. Sand: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate.
4. Proprietary Growing Mix: As submitted and acceptable to the Owner.
5. Sandy Loam Soil Mix: Sound, sharp, washed, natural sand or crushed stone complying with gradation requirements in ASTM C 33 for fine aggregate blended with planting soil as specified. Use blend consisting of 1/2 sand and 1/2 planting soil **OR** 2/3 sand and 1/3 planting soil, **as directed**.
6. Soil for Paving Fill: Planting soil as specified.

1.3 EXECUTION

A. Preparation

1. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
  - a. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
  - b. Protect grade stakes set by others until directed to remove them.
2. Install erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

B. Turf Area Preparation

1. Limit turf subgrade preparation to areas to be planted.
2. Newly Graded Subgrades: Loosen subgrade to a minimum depth of **4 inches (100 mm) OR 6 inches (150 mm) OR 8 inches (200 mm)**, **as directed**. Remove stones larger than **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm)**, **as directed**, in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off the Owner's property.
  - a. Apply superphosphate fertilizer directly to subgrade before loosening.
  - b. Thoroughly blend planting soil off-site before spreading or spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
    - 1) Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
    - 2) Mix lime with dry soil before mixing fertilizer.
  - c. Spread planting soil to a depth of **4 inches (100 mm) OR 6 inches (150 mm) OR 8 inches (200 mm)**, **as directed**, but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
    - 1) Spread approximately 1/2 the thickness of planting soil over loosened subgrade. Mix thoroughly into top **2 inches (50 mm) OR 4 inches (100 mm)**, **as directed**, of subgrade. Spread remainder of planting soil.
    - 2) Reduce elevation of planting soil to allow for soil thickness of sod.
3. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
  - a. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
  - b. Loosen surface soil to a depth of at least **6 inches (150 mm) OR 8 inches (200 mm)**, **as directed**. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top **4 inches (100 mm) OR 6 inches (150 mm)**, **as directed**, of soil. Till soil to a homogeneous mixture of fine texture.
    - 1) Apply superphosphate fertilizer directly to surface soil before loosening.
  - c. Remove stones larger than **1 inch (25 mm) OR 1-1/2 inches (38 mm) OR 2 inches (50 mm)**, **as directed**, in any dimension and sticks, roots, trash, and other extraneous matter.



- d. Legally dispose of waste material, including grass, vegetation, and turf, off the Owner's property.
  4. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus **1/2 inch (13 mm)** of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
  5. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
  6. Before planting, obtain the Owner's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- C. Preparation For Erosion-Control Materials
1. Prepare area as specified in "Turf Area Preparation" Article.
  2. For erosion-control mats, install planting soil in two lifts, with second lift equal to thickness of erosion-control mats. Install erosion-control mat and fasten as recommended by material manufacturer.
  3. Fill cells of erosion-control mat with planting soil and compact before planting.
  4. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.
  5. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- D. Preparation For Grass-Paving Materials
1. Reduce subgrade elevation soil to allow for thickness of grass-paving system. Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade so that installed paving is within plus or minus **1/2 inch (13 mm)** of finish elevation. Roll and rake, remove ridges, and fill depressions.
  2. Install base course **OR** sand course **OR** base course and sand course, **as directed**, and sandy loam soil mix **OR** proprietary growing mix **OR** soil for paving fill, **as directed**, as recommended by paving-material manufacturer for site conditions; comply with details shown on Drawings. Compact according to paving-material manufacturer's written instructions.
  3. Install paving mat and fasten according to paving-material manufacturer's written instructions.
  4. Before planting, fill cells of paving mat with planting soil **OR** sandy loam soil mix **OR** proprietary growing mix **OR** sand half full, **as directed**, and compact according to manufacturer's written instructions.
  5. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- E. Seeding
1. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds **5 mph (8 km/h)**. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
    - a. Do not use wet seed or seed that is moldy or otherwise damaged.
    - b. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
  2. Sow seed at a total rate of **2 lb/1000 sq. ft. (0.9 kg/92.9 sq. m)** **OR** **3 to 4 lb/1000 sq. ft. (1.4 to 1.8 kg/92.9 sq. m)** **OR** **5 to 8 lb/1000 sq. ft. (2.3 to 3.6 kg/92.9 sq. m)**, **as directed**.
  3. Rake seed lightly into top **1/8 inch (3 mm)** of soil, roll lightly, and water with fine spray.
  4. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets and 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.
  5. Protect seeded areas with erosion-control mats where shown on Drawings; install and anchor according to manufacturer's written instructions.
  6. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of **2 tons/acre (42 kg/92.9 sq. m)** to form a continuous blanket **1-1/2 inches (38 mm)** in loose thickness over seeded areas. Spread by hand, blower, or other suitable equipment.

- a. Anchor straw mulch by crimping into soil with suitable mechanical equipment.
    - b. Bond straw mulch by spraying with asphalt emulsion at a rate of **10 to 13 gal./1000 sq. ft. (38 to 49 L/92.9 sq. m)**. Take precautions to prevent damage or staining of structures or other plantings adjacent to mulched areas. Immediately clean damaged or stained areas.
  7. Protect seeded areas from hot, dry weather or drying winds by applying compost mulch **OR** peat mulch **OR** planting soil, **as directed**, within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of **3/16 inch (4.8 mm)**, and roll surface smooth.
- F. Hydroseeding
1. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
    - a. Mix slurry with nonasphaltic **OR** asphalt-emulsion **OR** fiber-mulch manufacturer's recommended, **as directed**, tackifier.
    - b. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than **1500-lb/acre (15.6-kg/92.9 sq. m)** dry weight, and seed component is deposited at not less than the specified seed-sowing rate.  
**OR**  
Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than **500-lb/acre (5.2-kg/92.9 sq. m)** dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of **1000 lb/acre (10.4 kg/92.9 sq. m)**.
- G. Sodding
1. Lay sod within 24 hours of harvesting. Do not lay sod if dormant or if ground is frozen or muddy.
  2. Lay sod to form a solid mass with tightly fitted joints. Butt ends and sides of sod; do not stretch or overlap. Stagger sod strips or pads to offset joints in adjacent courses. Avoid damage to subgrade or sod during installation. Tamp and roll lightly to ensure contact with subgrade, eliminate air pockets, and form a smooth surface. Work sifted soil or fine sand into minor cracks between pieces of sod; remove excess to avoid smothering sod and adjacent grass.
    - a. Lay sod across angle of slopes exceeding 1:3.
    - b. Anchor sod on slopes exceeding 1:6 with wood pegs or steel staples spaced as recommended by sod manufacturer but not less than 2 anchors per sod strip to prevent slippage.
  3. Saturate sod with fine water spray within two hours of planting. During first week after planting, water daily or more frequently as necessary to maintain moist soil to a minimum depth of **1-1/2 inches (38 mm)** below sod.
- H. Plugging
1. Plant plugs in holes or furrows, spaced **12 inches (300 mm) OR 18 inches (450 mm)**, **as directed**, apart in both directions. On slopes, contour furrows to near level.
- I. Sprigging
1. Plant freshly shredded sod sprigs in furrows **1 to 1-1/2 inches (25 to 38 mm) OR 1-1/2 to 2 inches (38 to 50 mm) OR 2-1/2 to 3 inches (64 to 75 mm)**, **as directed**, deep. Place individual sprigs with roots and portions of stem in moistened soil, **6 inches (150 mm) OR 12 inches (300 mm)**, **as directed**, apart in rows **10 inches (250 mm) OR 18 inches (450 mm)**, **as directed**, apart, and fill furrows without covering growing tips. Lightly roll and firm soil around sprigs after planting.
  2. Broadcast sprigs uniformly over prepared surface at a rate of **10 cu. ft./1000 sq. ft. (0.28 cu. m/92.9 sq. m)** and mechanically force sprigs into lightly moistened soil.
    - a. Spread a **1/4-inch- (6-mm-)** thick layer of compost mulch **OR** peat mulch **OR** planting soil, **as directed**, on sprigs.
    - b. Lightly roll and firm soil around sprigs after planting.





- c. Water sprigs immediately after planting and keep moist by frequent watering until well rooted.

J. Turf Renovation

1. Renovate existing turf.
2. Renovate existing turf damaged by Contractor's operations, such as storage of materials or equipment and movement of vehicles.
  - a. Reestablish turf where settlement or washouts occur or where minor regrading is required.
  - b. Install new planting soil as required.
3. Remove sod and vegetation from diseased or unsatisfactory turf areas; do not bury in soil.
4. Remove topsoil containing foreign materials such as oil drippings, fuel spills, stones, gravel, and other construction materials resulting from Contractor's operations, and replace with new planting soil.
5. Mow, dethatch, core aerate, and rake existing turf.
6. Remove weeds before seeding. Where weeds are extensive, apply selective herbicides as required. Do not use pre-emergence herbicides.
7. Remove waste and foreign materials, including weeds, soil cores, grass, vegetation, and turf, and legally dispose of them off the Owner's property.
8. Till stripped, bare, and compacted areas thoroughly to a soil depth of **6 inches (150 mm)**.
9. Apply soil amendments and initial fertilizers required for establishing new turf and mix thoroughly into top **4 inches (100 mm)** of existing soil. Install new planting soil to fill low spots and meet finish grades.
10. Apply seed and protect with straw mulch **OR** sod, **as directed**, as required for new turf.
11. Water newly planted areas and keep moist until new turf is established.

K. Turf Maintenance

1. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and remulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
  - a. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
  - b. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
  - c. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
2. Watering: Install and maintain temporary piping, hoses, and turf-watering equipment to convey water from sources and to keep turf uniformly moist to a depth of **4 inches (100 mm)**.
  - a. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
  - b. Water turf with fine spray at a minimum rate of **1 inch (25 mm)** per week unless rainfall precipitation is adequate.
3. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
  - a. Mow bentgrass to a height of **1/2 inch (13 mm)** or less.
  - b. Mow bermudagrass to a height of **1/2 to 1 inch (13 to 25 mm)**.
  - c. Mow carpetgrass, centipedegrass, perennial ryegrass, and zoysiagrass to a height of **1 to 2 inches (25 to 50 mm)**.
  - d. Mow Kentucky bluegrass, buffalograss, annual ryegrass, and chewings red fescue to a height of **1-1/2 to 2 inches (38 to 50 mm)**.

- e. Mow bahiagrass, turf-type tall fescue, and St. Augustinegrass to a height of **2 to 3 inches (50 to 75 mm)**.
  4. Turf Postfertilization: Apply fertilizer after initial mowing and when grass is dry.
    - a. Use fertilizer that will provide actual nitrogen of at least **1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m)** to turf area.
- L. Satisfactory Turf
  1. Turf installations shall meet the following criteria as determined by Architect:
    - a. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any **10 sq. ft. (0.92 sq. m)** and bare spots not exceeding **5 by 5 inches (125 by 125 mm)**.
    - b. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
    - c. Satisfactory Plugged Turf: At end of maintenance period, the required number of plugs has been established as well-rooted, viable patches of grass, and areas between plugs are free of weeds and other undesirable vegetation.
    - d. Satisfactory Sprigged Turf: At end of maintenance period, the required number of sprigs has been established as well-rooted, viable plants, and areas between sprigs are free of weeds and other undesirable vegetation.
  2. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.
- M. Meadow
  1. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds **5 mph (8 km/h)**. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
    - a. Do not use wet seed or seed that is moldy or otherwise damaged.
  2. Sow seed at a total rate of **4 oz./1000 sq. ft. (113 g/92.9 sq. m) OR 5 oz./1000 sq. ft. (142 g/92.9 sq. m) OR 6 oz./1000 sq. ft. (170 g/92.9 sq. m), as directed**.
  3. Brush seed into top **1/16 inch (1.6 mm)** of soil, roll lightly, and water with fine spray.
  4. Protect seeded areas from hot, dry weather or drying winds by applying peat or compost mulch within 24 hours after completing seeding operations. Soak areas, scatter mulch uniformly to a thickness of **3/16 inch (4.8 mm)**, and roll surface smooth.
  5. Water newly planted areas and keep moist until meadow is established.
- N. Meadow Maintenance
  1. Maintain and establish meadow by watering, weeding, mowing, trimming, replanting, and performing other operations as required to establish a healthy, viable meadow. Roll, regrade, and replant bare or eroded areas and remulch. Provide materials and installation the same as those used in the original installation.
    - a. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and meadow damaged or lost in areas of subsidence.
    - b. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
    - c. Apply treatments as required to keep meadow and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
  2. Watering: Install and maintain temporary piping, hoses, and meadow-watering equipment to convey water from sources and to keep meadow uniformly moist.
    - a. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
    - b. Water meadow with fine spray at a minimum rate of **1/2 inch (13 mm)** per week for four **OR** six **OR** eight, **as directed**, weeks after planting unless rainfall precipitation is adequate.



- O. Pesticide Application
  - 1. Apply pesticides and other chemical products and biological control agents in accordance with requirements of authorities having jurisdiction and manufacturer's written recommendations. Coordinate applications with the Owner's operations and others in proximity to the Work. Notify the Owner before each application is performed.
  - 2. Post-Emergent Herbicides (Selective and Non-Selective): Apply only as necessary to treat already-germinated weeds and in accordance with manufacturer's written recommendations.
- P. Cleanup And Protection
  - 1. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
  - 2. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
  - 3. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 32 91 13 33

NOT FOR BIDDING



Task	Specification	Specification Description
32 91 13 33	31 13 13 00	Tree Protection And Trimming
32 91 13 33	31 01 20 00	Earthwork
32 91 13 33	31 23 16 26	Embankment
32 91 13 36	32 91 13 16	Tree Relocation
32 91 13 36	32 91 13 33	Lawns And Grasses

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## SECTION 32 91 19 13 - CONCRETE REVETMENT

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers installation of a concrete revetment. Work includes but is not limited to furnishing all labor, materials, equipment and supervision necessary to construct concrete revetment as follows or as directed by the Owner.

### 1.2 PRODUCTS

- A. The Concrete Revetment shall be an articulating cellular concrete block system, as manufactured by American Excelsior Company, or approved equal, (800-713-8245), is a block structure installed over a geotextile fabric as described herein. The cellular blocks are made of Portland Cement Concrete cast into "lock" blocks and "key" blocks to provide a three directional interlock to resist lateral movement. The articulating cellular concrete block system is a "flexible" concrete revetment which allows the blocks to traverse changes in terrain without disruption of the placement pattern and interlock feature.

1. The minimum concrete strength shall be 3,000 psi. Nominal block thickness shall be either 4 inches, 6 inches or 8 inches, as required to meet project requirements. Block weights, per pair of "key" and "lock" blocks, shall be approximately 50, 70 and 90 pounds for #4010-4 inch, #4015-6 inch and #4020-8 inch thick blocks, respectively. Each pair of "key" and "lock" blocks shall cover approximately 1.54 square feet, including uncovered openings between the blocks. The system shall provide approximately 80 percent coverage of the area with blocks, leaving approximately 20 percent, but not less than 16 percent, uncovered area at the ground surface.

- B. Filter fabric shall be Tri-Lock Fabric #792 as supplied by American Excelsior Company, or approved equal, (800) 713-8245; roll values:

<u>Property</u>	<u>Specification</u>	<u>Test Method</u>
Weight	7.4 oz/sy	ASTM D3776
Thickness	25 mils	ASTM D1777
Permeability	0.5 cm/sec	ASTM D4491
Abrasion Resistance	Warp: 58 percent	ASTM N3884
(% strength retained)	Fill: 81 percent	
Tensile Grab Strength	350 lbs. x 395 lbs	ASTM D4632
Grab Elongation	24% x 24%	ASTM D4632
Burst Strength	780 psi	ASTM D3786
Trapezoid Tear	120 lbs x 110 lbs.	ASTM D4533
Puncture Strength	165 lbs.	ASTM D4833
Apparent Opening Size	40-70	ASTM D-4751
UV Resistance @ 500 hours	90 percent	ASTM D-4355

- C. Tri-Lock block size selection shall be determined from documented hydraulic characteristics, derived from test procedures outlined in: "Hydraulic Stability of Articulating Concrete block Revetment Systems During Overtopping Flow." Report No. FHWA-RD-89-199, and "Minimizing Embankment Damage During Overtopping Flow." Report No. FHWA-RD-88-181.

- D. Backfill: Topsoil and seeding shall be as per Division 31 Section(s) "Earth Moving" AND Division 32 Section(s) "Turf And Grasses".

### 1.3 EXECUTION



- A. Excavation shall be made so that the placement of the geotextile and concrete blocks shall be in conformity with the lines and grades shown on the plans or as required to meet project requirements. The area for placement shall be free from obstructions such as tree roots, projecting stones or other foreign matter and graded smooth. Voids or soft areas shall be filled with suitable materials and compacted to non-movement. Place the geotextile on the prepared subgrade. Lock the edges into a key trench as required to meet project requirements. The concrete blocks shall be assembled overlaying a geotextile in a manner that allows maximum flexibility but discourages vertical movement of any single component. Fill open areas of the blocks with concrete at the interface to concrete structure. After placement, the open areas of the block system shall be backfilled with topsoil to the top of the blocks. The backfilling shall be completed within 14 days of placement of the geotextile.

END OF SECTION 32 91 19 13

NOT FOR BID

## SECTION 32 91 19 13a - SEPTIC TANK SYSTEMS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for septic tank systems. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Septic tanks.
  - b. Distribution boxes.
  - c. Pipe and fittings.
  - d. Absorption systems

#### C. Submittals

1. Product Data: For each type of product indicated.
  - a. Include construction details, material descriptions, dimensions of individual components, and profiles.
  - b. Include manhole openings, covers, and pipe connections.
2. Shop Drawings: For [trench absorption systems] [bed absorption systems].
  - a. Include manhole openings, covers, pipe connections, and accessories.
  - b. Include piping with sizes and invert elevations.
  - c. Include underground structures.
  - d. Include other utilities.

### 1.2 PRODUCTS

#### A. Septic Tanks

1. Precast Concrete Septic Tanks: ASTM C 1227, single-chamber **OR** two-chamber, **as directed**, precast, reinforced-concrete tank with internal baffle, **as directed**, and covers.
  - a. Design: For A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed**, traffic loading according to ASTM C 890.
  - b. Manholes: **20-inch- (508-mm-) OR 22-inch- (559-mm-) OR 24-inch- (610-mm-), as directed**, minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.
  - c. Filter Access: Reinforced-concrete access hole, large enough to remove filter, over filter position.
  - d. Inlet and Outlet Access: **12-inch- (300-mm-)** minimum diameter, reinforced-concrete access lids with steel lift rings. Include access centered over inlet and outlet.
  - e. Resilient Connectors: **ASTM C 923 (ASTM C 923M)**, of size required for piping, fitted into inlet and outlet openings.
2. Fiberglass Septic Tanks: UL 1316, single-chamber, FRP construction; fabricated for septic tank application with at least one access riser and manhole.
  - a. Manholes: **22-inch- (559-mm-) OR 24-inch- (610-mm-), as directed**, minimum diameter opening with FRP access risers to grade and cover.
  - b. Filter Access: Include access hole, large enough to remove filter, over filter position.
  - c. Resilient Connectors: **ASTM C 923 (ASTM C 923M)** or other watertight seal, of size required for piping, fitted into inlet and outlet openings.
3. Polyethylene Septic Tanks: Single-chamber, molded, HDPE or PE construction; fabricated for septic tank application, with baffle, **as directed**, and at least one access riser and manhole.





4. Polyethylene Septic Tanks: Two-chamber, molded, HDPE or PE construction; fabricated for septic tank application, with access risers and manholes.
  - a. Manholes: **18-inch- (457-mm-) OR 20-inch- (508-mm-) OR 22-inch- (559-mm-), as directed**, minimum diameter opening with HDPE or PE access risers to grade and cover.
  - b. Filter Access: Include access hole, large enough to remove filter, over filter position.
  - c. Resilient Connectors: **ASTM C 923 (ASTM C 923M)** or other watertight seal, of size required for piping, fitted into inlet and outlet openings.
- B. Filters
  1. Description: Removable, septic-tank-outlet filter that restricts discharge solids to **1/8 inch (3.2 mm)**.
    - a. Housing: HDPE or PVC.
    - b. Outlet Size: **NPS 4 (DN 100) OR NPS 6 (DN 150), as directed.**
- C. Dosing Tanks
  1. Dosing Tanks: Comply with ASTM C 913 for precast, reinforced-concrete tank and cover; designed for structural loading according to ASTM C 890.
    - a. Design: For effluent pump, **OR** automatic siphon, **as directed**, installation and A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed**, traffic loading according to ASTM C 890.
    - b. Manholes: **20-inch- (508-mm-) OR 22-inch- (559-mm-) OR 24-inch- (610-mm-), as directed**, minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings. Include manhole in center of each septic tank compartment top.
    - c. Resilient Connectors: **ASTM C 923 (ASTM C 923M)**, of size required for piping, fitted into inlet and outlet openings.
- D. Automatic Siphons
  1. Description: Manufactured siphon assembly of molded-HDPE trap, pipe, and bell, with PVC vent piping and stainless-steel bolts.
- E. Distribution Boxes
  1. Description: Precast concrete, single-chamber box and cover.
    - a. Design: Made according to ASTM C 913, and for A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed**, traffic loading according to ASTM C 890. Include baffle opposite inlet.
    - b. Manholes: **20-inch- (508-mm-) OR 22-inch- (559-mm-) OR 24-inch- (610-mm-), as directed**, minimum diameter opening with reinforced-concrete risers to grade and cover with steel lift rings in center of distribution box cover.
    - c. Pipe Connections: **ASTM C 923 (ASTM C 923M)** resilient connectors, of size required for piping, fitted into inlet and outlet openings. Include watertight plugs in outlets not required.
  2. Description: Molded-HDPE or -PE, single-chamber box and cover.
    - a. Manholes: **18-inch- (457-mm-) OR 20-inch- (508-mm-) OR 22-inch- (559-mm-), as directed**, minimum diameter opening with HDPE or PE access risers to grade and cover. Access for PE distribution boxes may be a removable plastic cover and is usually small.  
**OR**  
Manufacturer's standard cover or other access opening of size that permits access to distribution-box inlet and outlets.
    - b. Pipe Connections: With seal that prevents leakage. Include watertight plugs in outlets not required.
- F. Leaching Pipes And Fittings
  1. Pipe: PE, complying with ASTM F 810, perforated.
    - a. Fittings: ASTM D 2729 PVC for loose joints; ASTM D 3034, PVC for gasketed joints; or ASTM D 2751, ABS for gasketed joints.

2. Tube and Fittings: PE, complying with ASTM F 405, perforated corrugated tube with solid-wall fittings.
    - a. Couplings: PE band, matching tube and fitting dimensions.
  3. Pipe and Fittings: PVC, complying with ASTM D 2729, perforated, for solvent-cement joints.
    - a. Solvent Cement: ASTM D 2564. Include primer according to ASTM F 656
  4. Drainage Tile: Clay drain tile, complying with ASTM C 4, Standard class, drain tile with regular and smooth ends, for open joints.
- G. Nonpressure-Type Pipe Couplings
1. Description: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant-metal tension band and tightening mechanism on each end.
    - a. Sleeve Materials:
      - 1) For Concrete Pipes: **ASTM C 443 (ASTM C 443M)**, rubber.
      - 2) For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
      - 3) For Vitrified-Clay Pipes: ASTM C 425, rubber.
      - 4) For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- H. Leaching Chambers
1. Description: Arched, molded-PE structures with solid top, perforated sides, open ends, and open bottom.
    - a. End Pieces: Solid and solid with pipe opening types.
    - b. Effluent Distribution Piping: PE or PVC pipe, with holes or slots along pipe, attached to underside of top of chambers.
- I. Trench **OR** Bed, **as directed**, Absorption-System Materials
1. Filtering Material: ASTM D 448, Size No. 24, **3/4 to 2-1/2 inches (19 to 63 mm)**, washed, crushed stone or gravel; or broken, hard-burned clay brick.
  2. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total unit weight of **3 oz./sq. yd. (101 g/sq. m)** **OR** Untreated building paper or similar porous material, **as directed**.
  3. Cover for Distribution Pipe: Geotextile woven filter fabric, in 1 or more layers, for minimum total unit weight of **3 oz./sq. yd. (101 g/sq. m)**.
  4. Fill Material: Soil removed from trench.
- J. Mound Absorption-System Materials
1. Sand Filtering Material: 25 percent or more of very coarse, coarse, or medium sand or combination; maximum of 50 percent fine or very fine sand or combination; and silt and clay combination not to exceed 25 percent. If clay exceeds 60 percent in combination with silt, mixture cannot exceed 15 percent of sand filtering material.
  2. Aggregate Filtering Material: Coarse, **1/2 to 2-1/2 inches (13 to 63 mm)**.
  3. Cap: Clay, silt, or combination of clay and silt.
  4. Topsoil: Good quality, free of stones, metal, and glass.
  5. Vegetation Cover: Grass compatible with adjacent ground cover. No shrubs or trees.
  6. Filter Mat: Geotextile woven or spun filter fabric, in 1 or more layers, for minimum total unit weight of **3 oz./sq. yd. (101 g/sq. m)** **OR** Untreated building paper or similar porous material, **as directed**.
  7. Cover for Distribution Pipe: Geotextile woven filter fabric, in 1 or more layers, for minimum total unit weight of **3 oz./sq. yd. (101 g/sq. m)**.
- K. Chamber Absorption-System Materials
1. Chamber: Arched, molded-PE structures with solid top, perforated sides, open ends, and open bottom.
  2. End Pieces: Blank without opening for distribution pipe at end of last chamber in row, and with opening for distribution pipe where pipe penetrates chamber.

3. Retain first paragraph below to run piping through chambers to improve distribution.
4. Effluent Distribution Piping: PE or PVC pipe, with holes or slots along pipe, attached to underside of top of chambers.

L. Seepage Pit Absorption-System Materials

1. Constructed-in-Place-Type Seepage Pit: Include the following materials.
  - a. Pit Lining: ASTM C 62, Type SW, clay bricks; ASTM C 55, concrete bricks; ASTM C 90, hollow, concrete masonry units; or precast concrete rings with notches or weep holes.
  - b. Filtering Material: ASTM D 448, Size No. 24, **3/4 to 2-1/2 inches (19 to 63 mm)**, washed, crushed stone or gravel; or broken, hard-burned clay brick.
  - c. Cover: Precast concrete slab; designed for A-8 (H10-44) **OR** A-12 (HS15-44) **OR** A-16 (HS20-44), **as directed**, traffic loading according to ASTM C 890 and made according to ASTM C 913. Include slab dimensions that will extend minimum of **12 inches (300 mm)** beyond edge of excavation. Cast cover with opening for manhole in center.
  - d. Manholes: **20-inch- (508-mm-) OR 22-inch- (559-mm-) OR 24-inch- (610-mm-), as directed**, minimum diameter opening with reinforced-concrete risers to grade and access lid with steel lift rings.

### 1.3 EXECUTION

A. Earthwork

1. Excavating, trenching, and backfilling for piping and seepage pits are specified in Division 31 Section "Earth Moving".
  - a. Stockpile topsoil for reuse in finish grading without intermixing with other excavated material. Stockpile materials away from edge of excavation and do not store within drip line of remaining trees.
  - b. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.
2. Excavating and Backfilling for Septic and Dosing Tanks:
  - a. Excavate sufficient width and length for tanks to depth determined by tank inlet elevation. Provide level bottom.
  - b. Backfill with excavated soil, mounding soil above original grade without compacting.
3. Excavating and Backfilling for Trench **OR** Bed, **as directed**, Absorption Fields:
  - a. Excavate for trench absorption fields **30 inches (762 mm)** wide and **24 inches (600 mm)** deep, minimum.
  - b. Backfill trench absorption fields with excavated soil, mounding soil above original grade without compacting.
  - c. Excavate for bed absorption fields of width indicated and **24 inches (600 mm)** deep, minimum.
  - d. Backfill bed absorption fields with excavated soil, mounding soil above original grade without compacting.

B. Excavating and Backfilling for Chamber Absorption Systems:

1. Excavate for trench-type chamber absorption systems **30 inches (762 mm)** wide and **24 inches (610 mm)** deep, minimum.
2. Excavate for bed-type chamber absorption systems of width indicated and **24 inches (610 mm)** deep, minimum.
3. Backfill chamber absorption systems with excavated soil, mounding soil above original grade without compacting.

C. Excavating and Backfilling for Seepage-Pit Absorption Systems:

1. Excavate sufficient hole diameter for pits to depth determined by tank inlet and bottom elevations. Provide level bottom.
2. Backfill with excavated soil, mounding soil above original grade without compacting.

- D. Septic Tank Installation
1. Install precast concrete septic tanks level according to ASTM C 891.
  2. Install septic tanks level.
  3. Connect septic tank to concrete ballast pad.
  4. Install filter in septic tank outlet. Secure filter to septic tank wall. Make direct connections to distribution piping.
  5. Install insulation on exterior sides and top of septic tank.
  6. Fill septic tank with water.
- E. Dosing Tank Installation
1. Install dosing tanks level and according to ASTM C 891.
  2. Install automatic siphons embedded in precast concrete dosing tank. Make direct connections to distribution piping.
  3. Set submersible effluent pumps on dosing tank floor. Make direct connections to distribution piping.
  4. Fill dosing tanks with water.
- F. Distribution Box Installation
1. Install precast concrete distribution boxes according to ASTM C 891 and at invert elevations indicated. Set level and plumb.
  2. Install PE distribution boxes at invert elevations indicated and according to manufacturer's written instructions. Set level and plumb.
- G. Piping Installation
1. Install leaching piping according to the following:
    - a. Use perforated pipe and fittings for trench **OR** bed **OR** mound, **as directed**, absorption fields with perforations at bottom.
    - b. PE Tube and Fittings: ASTM F 481.
    - c. PVC Sewer Pipe and Fittings: ASTM F 481.
- H. Pipe Joint Construction
1. Basic piping joint construction is specified in Division 33 Section "Common Work Results For Utilities". Where specific joint construction is not indicated, follow piping manufacturer's written instructions.
  2. Join distribution piping with or according to the following:
    - a. Install leaching pipe and fittings for trench **OR** bed **OR** mound, as directed, absorption fields with closed joints, unless otherwise indicated.
    - b. PE Tube and Fittings: With PE band couplings.
    - c. PVC Sewer Pipe and Fittings: With solvent-cemented joints according to ASTM F 402 and ASTM D 2321.
  3. Join dissimilar pipe materials according to ASTM D 5926, with couplings and gaskets compatible with pipe materials being joined.
- I. Cleanout Installation
1. Install cleanouts according to the following:
    - a. Inlet and Outlet of Septic Tanks: Cast-iron cleanouts.
    - b. Inlet and Outlet of Dosing Tanks: Cast-iron cleanouts.
    - c. Inlet and Outlet of Distribution Boxes: Cast-iron **OR** PVC cleanouts.
    - d. At Each Change in Direction of Sewer Piping: Cast-iron **OR** PVC cleanouts.
    - e. At Ends of Each Row and at Each Change in Direction of Distribution Piping: Cast-iron **OR** PVC cleanouts.
  2. Cast-Iron Cleanouts: Install with PVC fitting riser from distribution and leaching piping to cast-iron cleanout housing at grade. Use **NPS 4 (DN 100)** PVC sewer pipe and fittings with solvent-cemented joints for risers. Attach riser to cleanout housing with rubber gasket or coupling.

3. PVC Cleanouts: Install with PVC riser from distribution and leaching piping to PVC cleanout at grade. Use **NPS 4 (DN 100)** PVC sewer pipe and fittings with solvent-cemented joints for risers and cleanout fitting.
4. Cleanout Support: Set cleanouts in concrete blocks **18 by 18 by 12 inches (457 by 457 by 305 mm)** deep, unless location is in concrete pavement. Formwork, reinforcement, and concrete are specified in Division 03 Section "Cast-in-place Concrete".
5. Set top of cleanout **1 inch (25 mm) OR 2 inches (50 mm)**, **as directed**, above surrounding rough grade, or set flush with grade if installed in pavement.

J. Trench **OR** Bed **OR** Absorption-Field, **as directed**, Installation

1. Filtering Material: Place supporting layer of filtering material over the compacted trench **OR** bed, **as directed**, base to a compacted depth not less than **6 inches (150 mm)** below bottom of pipe.
2. Refer to Part 1.3 "Piping Installation" and "Pipe Joint Construction" articles for specific piping material installation.
3. Install distribution piping at minimum slope of 1 percent and maximum slope of 2 percent.
4. Install leaching piping solidly bedded in filtering material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.
  - a. Install perforated pipe with perforations down and joints tightly closed. Install collars and couplings as required.
  - b. Install open-joint pipe with **1/2-inch (13-mm)** space, maximum, between ends, unless otherwise indicated. Cover top two-thirds of joint opening with joint cover, and tie with corrosion-resistant wire. Commercial joint-cover assemblies may be provided.
  - c. Install elbow fittings with tight joints.
  - d. Place additional filtering material around sides to a minimum compacted depth of **8 inches (200 mm)** above the top of leaching piping.
5. Install filter mat over filter material before backfilling.
6. Install leaching chambers with no slope in bottom of trench **OR** bed, **as directed**.
  - a. Install leaching chamber distribution piping with tight joints throughout chambers.
7. Backfill according to Part 1.3 "Earthwork" Article.

K. Mound Absorption-Field Installation

1. Plow top **6 inches (150 mm)** of surface.
2. Place layers of sand, aggregate, **as directed**, cap, and topsoil above plowed area. Provide grass topping to match adjacent vegetation. Provide side slope not steeper than 3:1. Tie slope toe smoothly into existing grade.
3. Refer to Part 1.3 "Piping Installation" and "Pipe Joint Construction" articles for specific piping material installation.
4. Provide solid vent pipe with vent cap extending **12 inches (300 mm)** above top of mounds.
5. Install distribution piping with no slope for pressurized effluent system.
6. Install distribution piping at a minimum slope of 1 percent and a maximum slope of 2 percent for gravity effluent system.
7. Install leaching piping solidly bedded in filtering material, with full bearing for each pipe section throughout its length. Maintain pipe alignment with no slope.
  - a. Install perforated pipe with perforations down and joints tightly closed. Install collars and couplings as required.
  - b. Install open-joint pipe with **1/2-inch (13-mm)** space, maximum, between ends, unless otherwise indicated. Cover top two-thirds of joint opening with joint cover, and tie with corrosion-resistant wire. Commercial joint-cover assemblies may be provided.
  - c. Install elbow fittings with tight joints.
8. Install leaching chambers with no slope above plowed area.
  - a. Install leaching chamber distribution piping with tight joints throughout chambers.
9. Provide adequate grading around mound absorption field to prevent storm runoff from washing away a portion of mound absorption field and to prevent exposing pipes.

L. Seepage Pit Installation



1. Excavate hole to minimum diameter of **6 inches (150 mm)** greater than outside of pit lining.
2. Do not extend pit depth into ground-water table.
3. Install constructed-in-place seepage pits according to the following procedure if no requirements of authorities having jurisdiction apply:
  - a. Install brick pit lining material dry and laid flat with staggered joints for seepage.
  - b. Install block pit lining material dry with staggered joints and a minimum of 20 percent of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage.
  - c. Extend pit lining material so top of manhole will be approximately **8 inches (200 mm)** below finished grade.
  - d. Backfill bottom of inside of pit with filtering material at least **12 inches (300 mm)** above bottom of lining material.
  - e. Extend effluent inlet pipe **12 inches (300 mm)** into seepage pit and terminate into side of tee fitting.
  - f. Backfill around outside of pit lining with filtering material to top of lining.
  - g. Install manhole risers from top of pit to grade. Support cover on undisturbed soil. Do not support cover on pit lining.

M. Identification

1. Identification materials and their installation are specified in Division 31 Section "Earth Moving". Arrange for installation of green warning tape directly over piping (including absorption-field piping), at outside edges of underground structures, and at outside edges of absorption fields.
2. Use detectable warning tape over piping, over edges of underground structures, and over edges of absorption fields.

N. Field Quality Control

1. System Tests: Perform testing of completed septic tank system piping and structures according to authorities having jurisdiction.
2. Additional Tests: Fill underground structures with water and let stand overnight. If water level recedes, locate and repair leaks and retest. Repeat tests and repairs until no leaks exist.

O. Cleaning

1. Clear interior of piping and structures of dirt and other superfluous material as work progresses.
2. Maintain swab or drag in piping, and pull past each joint as it is completed. Place plugs in ends of uncompleted pipe at end of workday or when work stops.

END OF SECTION 32 91 19 13a

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Task	Specification	Specification Description
32 91 19 13	02 41 13 13a	Portland Cement Concrete Removal
32 91 19 13	31 11 00 00	Site Clearing
32 91 19 13	31 13 13 00	Tree Protection And Trimming
32 91 19 13	31 01 20 00	Earthwork
32 91 19 13	31 23 16 26	Embankment
32 91 19 13	32 91 13 33	Lawns And Grasses
32 92 16 00	32 91 13 33	Lawns And Grasses
32 92 19 13	32 91 13 33	Lawns And Grasses
32 92 19 19	32 91 13 33	Lawns And Grasses
32 92 23 00	32 91 13 33	Lawns And Grasses
32 93 13 00	32 14 09 00	Exterior Plants
32 93 23 00	32 14 09 00	Exterior Plants
32 93 33 00	31 11 00 00	Site Clearing
32 93 33 00	32 14 09 00	Exterior Plants
32 93 43 00	32 14 09 00	Exterior Plants
32 93 83 00	31 13 13 00	Tree Protection And Trimming
32 93 83 00	32 91 13 16	Tree Relocation
32 93 83 00	32 14 09 00	Exterior Plants
32 94 13 00	32 14 09 00	Exterior Plants
32 94 16 00	32 14 09 00	Exterior Plants
32 94 43 00	01 22 16 00	No Specification Required
32 94 43 00	32 33 13 00	Miscellaneous Site and Street Furnishings
32 94 49 00	01 22 16 00	No Specification Required
32 94 49 00	31 13 13 00	Tree Protection And Trimming
32 94 49 00	32 14 09 00	Exterior Plants
32 96 33 00	32 91 13 16	Tree Relocation
32 96 43 00	32 91 13 16	Tree Relocation



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## SECTION 33 01 10 58 - REPAIR AND MAINTENANCE OF IMHOFF TANKS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for repair and maintenance of sewage treatment plant Imhoff tanks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

#### A. Coatings:

1. Epoxy-Filler Compound for concrete surfaces shall comply with Fed. Spec. MMM-A-001993.
2. Coal-Tar Epoxy shall comply with SSPC-PAINT 16.
3. Epoxy Paint shall comply with Mil. Spec. MIL-P-24441.
4. Red-Lead Base Paint shall comply with Fed. Spec. TT-P-86, Type I.
5. Aluminum Finish Paint shall comply with Fed. Spec. TT-P-38.

- #### B. Steel Tank Repair Material for minor leaks shall be a two-component epoxy sealing compound. For badly corroded areas, a steel plate of the same composition and thickness as the original tank shall be used.

- #### C. Pipe and Fittings for replacement shall be equivalent to the existing pipe and fittings.

### 1.3 EXECUTION

- #### A. Preparation: Drain the contents of the tank and dispose of the sludge and sewage.

#### B. Leak Repair:

1. Concrete Tanks: Repair concrete tank leaks by cleaning and chipping or sandblasting the area of the leak and applying two-component epoxy concrete sealant.
2. Steel Tanks: Repair steel tank leaks by cleaning, scraping, chipping, or sandblasting the area of the leak and applying epoxy steel sealant. Repair badly corroded areas of steel tanks by cutting out the corroded area and welding a section of new steel plate in place. Welding shall be in compliance with AWS D1.1.

- #### C. Pipe and Fittings: Replace pipe and fittings as required.

#### D. Cleaning and Coatings:

1. Interior Concrete Surfaces of the tank shall be cleaned with high pressure water or steam to remove dirt and residue, allowed to dry, and brush sandblasted.
2. Holes and Voids in the concrete surfaces left from the blast cleaning shall be filled by means of troweling and squeeze application of epoxy filler. Two coats of coal-tar epoxy shall be applied to the surface after the epoxy has cured.
3. Submerged Ferrous Metal Surfaces such as piping and equipment that are exposed to the sewage shall be sandblasted and coated with two coats of coal-tar epoxy.



4. Exterior Concrete Surfaces of the tank shall be cleaned by means of brush sandblast. The surfaces shall be blown down with air to remove the blasting residue and dust, and two coats of epoxy-polyamide paint shall be applied.
5. Ferrous Metal Surfaces that are not submerged shall be cleaned by means of sandblasting. Coat surfaces with one coat of red-lead base paint. After the base paint has dried sufficiently, apply two coats of aluminum finish paint.

END OF SECTION 33 01 10 58

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## SECTION 33 01 10 58a - SEWER LINE CLEANING

### 1.1 GENERAL

- A. Description Of Work
  - 1. This specification covers sewer line cleaning. Cleaning procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.
- B. Submittals: Submit product data and manufacturer's instruction.

### 1.2 PRODUCTS

- A. All materials shall be clean, free of defects, corrosion, and damage. All items shall be of proper type, size, design, and characteristics for the use intended. Unless otherwise specified, all items shall be factory-made.
- B. Portable Cleaning Equipment: Equipment used in the cleaning of sewer lines shall be as required to complete the work for the size, length, and conditions of the sewer. Portable and mobile equipment shall comply with Water Pollution Control Federation Manual No. 7.
- C. Chemicals shall be of the strength required to perform the work. The chemicals shall not be damaging to pipe materials, manholes, pumping equipment, nor treatment process and shall not be contaminated by foreign substances.

### 1.3 EXECUTION

- A. Preparation
  - 1. Protection required to prevent damage to adjacent materials, equipment, fixtures, and finishes shall be provided. Necessary protective clothing and accessories for personnel working with chemicals shall be provided.
  - 2. Ventilation of Sewers: Contractor shall provide proper ventilation for personnel working in the sewer.
  - 3. Alternate Sewage Discharge: Contractor shall provide an alternate routing of sewage discharge to a downstream manhole.
  - 4. Traffic: Contractor shall provide all traffic signs required to safely direct traffic at and around work areas.
- B. Installation
  - 1. Direction of Work: Sewer line cleaning work, with the exception of hydraulic scouring, shall proceed in the downstream direction. Cleaning by hydraulic scouring shall proceed in the upstream direction.
  - 2. Testing: Upon completion of cleaning operation, test sewer lines for proper operation and observe for a period of 24 hours. Clean out all stoppages and the retest the line for proper operation.

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Task	Specification	Specification Description
33 01 10 58	21 05 23 00	Piped Utilities Basic Materials And Methods

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## SECTION 33 01 10 71 - PIPE LINING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of pipe lining. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

### 1.2 PRODUCTS

#### A. Lining Material:

1. Polyethylene Pipe: Extruded, flexible industrial grade, high density (Type 3 or 4) in 40 foot lengths, complying with ASTM D 2239 and D 2447.
  - a. Diameter: Outside diameter shall be as large as possible while allowing for ease of pulling into the existing pipes. Pipe dimensions shall comply with ASTM D 2447 and D 2837.
  - b. Liner Thickness and Class shall be suitable for the use intended. The tolerance on the pipe wall thickness shall be as noted in Table 2 of ASTM D 2447.
  - c. Gravity Sanitary, Gravity Storm, and Gravity Industrial Sewers shall be Schedule 40.
  - d. Gravity Thermal Discharge Sewers shall be Schedule 80.
  - e. Low Pressure Sewers shall be Schedule 40, complying with ASTM D 2239.
  - f. High Pressure Sewers shall be Schedule 80, complying with ASTM D 2239 and D 2837.
  - g. Chemical Resistance: Pipe liner shall be resistant to chemical attack, erosion, and corrosion.
  - h. Fittings shall be fabricated from polyethylene pipe. The polyethylene fittings shall have the same pressure rating as the pipe and shall comply with ASTM D 3261.
2. Cement-Mortar Lining:
  - a. Portland Cement shall comply with ASTM C 150, Type 1.
  - b. Pozzolan Cement shall comply with ASTM C 618 and shall not comprise more than 20 percent of total cement amount, by weight.
  - c. Sand shall be well graded, clean, free from organic and extraneous matter. One hundred percent shall pass the 16-mesh size screen.
  - d. Lining Thickness: Cement lining shall be not less than 1/8 inch for pipe sizes 4 to 14 inches, not less than 3/16 inch for pipe sized 16 inches and larger, and not less than 1/4 inch for steel pipe 16 inches and larger.
3. Reinforced Mortar Pipe Slip-Lining:
  - a. Gravity Sewers: Slip-lining shall be of glass fiber reinforced polyester mortar pipe, complying with ASTM D 3262.
  - b. Pressure Sewers (Force Mains): Slip-lining shall be of glass fiber reinforced polyester mortar pipe complying with ASTM D 2517.
  - c. Diameter: Outside diameter shall be as large as possible while allowing for ease of pulling into existing pipes, as recommended by the manufacturer.
  - d. Chemical Resistance: Pipe liner shall be resistant to chemical attack, erosion, and corrosion.
4. Fittings: Fittings shall be manufactured of the same materials as is the glass fiber reinforced polyester mortar pipe.
5. Epoxy-Mortar Lining:
  - a. Epoxy compound shall comply with ASTM D 1763.
  - b. Admixtures shall be well graded with one hundred percent passing. The 16-mesh size screen. All admixtures shall improve the workability, density, and strength of the mortar.



- c. Lining Thickness: For pipe sizes 4 to 14 inches, epoxy mortar lining thickness shall be not less than 1/8 inch. For pipe sizes 16 inches and larger, epoxy mortar lining shall be not less than 3/16 inch.

B. Joint:

1. Slip-Lining:

- a. Polyethylene Pipe Butt Joints: Pipe lengths, fittings, and flanged connections to be joined by thermal butt fusion shall be of the same time, grade, and class of polyethylene compound and supplied by pipe supplier.
- b. Flanged Joints shall consist of a polyethylene flange, thermally butt fused to the ends of the pipe. The companion flange shall be steel or cast iron and nylon-coated.
- c. Lateral Service Connections: Sidewall connections shall be made with polyethylene pipe sections of the same material, grade, and class as the liner material and shall have the same pressure ratings. Lateral connections shall be watertight.

2. Reinforced Mortar Lining:

- a. Bell and spigot joints shall be the inverted type.
- b. Manhole Joints and Connections shall be oakum ring and grout as required.

1.3 EXECUTION:

A. Slip-Lining, Polyethylene Pipe:

- 1. Insertion of Liner: Liner shall be laid at a constant line and grade as the existing pipe, without undulations or damage. Where the existing pipe is not at constant grade, the liner shall follow as true a constant grade as possible.
- 2. Grouting: At manholes, annular space shall be packed with oakum and expansion grout or nonshrink grout as required. At existing line, after liner has been inserted, grout wherever existing pipe has failed structurally.
- 3. Concrete Encasement: Crown of liner shall be encased in concrete a minimum thickness of 6 inches for the entire length of the excavated trench and out at least 6 inches each side of the bottom half of the original pipe remaining down to firm soil. Wherever existing concrete encasement has been removed, the liner shall be encased in the same manner as the original pipe.
- 4. Thrust Blocks: Concrete thrust blocks shall be provided as required.

B. Cement Mortar and Epoxy Mortar Lining:

- 1. Cement Mortar Mixing: One part cement to one and one-half parts of sand by volume.
- 2. Application of Lining: The lining shall be applied to produce a smooth, uniform thickness throughout the interior of the pipe line.
- 3. Curing of the Cement Mortar Lining: Immediately upon completion of the lining of a length of pipe between access openings or at the end of a day's run, the section of pipe shall be closed at each end, the access openings covered to prevent the circulation of air, and the atmosphere kept moist.
- 4. Reconnection of Pipes After Lining: Close and make watertight all openings in the lines.
- 5. Pressure Test and Leaks: Hydrostatic and leakage tests shall be conducted on all pipe that is cleaned and lined.

C. Reinforced Mortar Pipe Lining:

- 1. Joining of Pipe Ends: Liner sections containing bell and spigot joints shall be joined using an O-ring.
- 2. Grouting Work shall be accomplished following the same techniques as described in paragraph Slip-Lining, Polyethylene Pipe.

D. Cement Mortar Lining:

1. Epoxy Mortar Lining: Excessive mortar shall be removed from the manhole walls and bottom. Manhole bottom shall receive special care in making all transitions smooth.
2. Work at Service Connections: Plugs or caps shall be placed at the access point of the service connection to the lines and shall be removed once the mortar has set. The completed lining shall not be damaged.
3. Reinforced Mortar Pipe Lining: Joining of fiberglass reinforced polyester mortar pipe shall be carried out in the trench, with the first section of liner already inserted.
4. Lateral Connections: Service to connections shall be provided for and continued after installation of the lining.
5. Testing: Upon completion of lining operation, the sewer line shall be tested for proper operation and shall be observed for a period of 24 hours. All deficiencies shall be corrected.
6. Pavement Restoration: All disturbed pavement shall be restored to its original condition and shall match existing adjacent.
7. Inspection: Large diameter sewers shall be inspected from inside to ensure that all lateral connections and joints are in proper order. Sewers that have been cement-lined may be inspected for a smooth finish, while plugs and caps are being removed.

END OF SECTION 33 01 10 71

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Task	Specification	Specification Description
33 01 10 71	01 22 16 00	No Specification Required
33 01 10 71	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 11	01 22 16 00	No Specification Required
33 01 30 41	33 01 10 58a	Sewer Line Cleaning
33 01 30 42	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 42	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 42	33 01 10 58a	Sewer Line Cleaning
33 01 30 74	01 22 16 00	No Specification Required

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## SECTION 33 01 30 81 - REPAIR AND MAINTENANCE OF SIPHON TANK AND SIPHONS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for the repair and maintenance of sewage treatment plant dosing siphon tanks. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

- A. Tank Repair Material shall be epoxy type grout complying with Fed. Spec. MMM-A-001993.

#### B. Concrete Coatings:

1. Outside and Above Grade shall be epoxy type in compliance with Mil. Spec. MIL-P-24441.
2. Inside and Below Grade shall be coal-tar epoxy type in compliance with SSPC-PAINT 16.

- C. Steel Repair Material shall be steel plate or epoxy cement and fiberglass cloth.

- D. Corroded or Defective Siphons: Replace those parts corroded or defective with new parts compatible with the unit, as recommended by the manufacturer.

#### E. Steel Coatings:

1. Red-Lead Base Coat shall comply with Fed. Spec. TT-P-86, Type I.
2. Aluminum Paint shall comply with Fed. Spec. TT-P-38.

### 1.3 EXECUTION

- A. Corroded or Broken Pipe and Fittings: Replace as required.

- B. Minor Leaks: Repair minor leaks in the tank using material and surface preparation and application methods recommended by the material manufacturer.

- C. Spalled Areas: Repair as required.

#### D. Cleaning and Coating:

1. Interior Concrete Surfaces of the tank shall be cleaned with high pressure water or steam to remove all dirt and residue, allowed to dry, and brush sandblasted in compliance with SSPC-SP 7.
2. The Exterior Concrete Surfaces of the tank shall be cleaned by means of brush sandblasting in compliance with SSPC-SP 7. The surfaces shall be blown down with air to remove the blasting residue and dust, and two coats of epoxy-polyamide paint shall be applied.
3. Holes and Voids in the concrete surfaces left from the blast cleaning shall be filled by means of troweling and squeeze application of an epoxy filler. The surfacing material shall be allowed to cure overnight, and then two coats of coal-tar epoxy complying with SSPC-PAINT 16 shall be applied.



4. Submerged Ferrous Metal Surfaces that are exposed to the sewage shall be sandblasted in compliance with SSPC-SP 10 and coated with two coats of coal-tar epoxy.
5. Ferrous Metal Surfaces that are not submerged shall be cleaned by means of sandblasting in compliance with SSPC-SP 6. Surfaces inaccessible to sandblasting shall be power tool cleaned in compliance with SSPC-SP 3. Surfaces shall be coated with one coat of red-lead base paint. After the base paint has dried sufficiently, two coats of aluminum finish paint shall be applied.

END OF SECTION 33 01 30 81

NOT FOR BID

## SECTION 33 01 30 81a - UNDERGROUND DUCTS AND UTILITY STRUCTURES

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for underground ducts and utility structures. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes the following:
  - a. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs\.
  - b. Handholes and pull boxes.
  - c. Manholes.

#### C. Definition

1. RNC: Rigid nonmetallic conduit.

#### D. Submittals

1. Product Data: For the following:
  - a. Duct-bank materials, including separators and miscellaneous components.
  - b. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
  - c. Accessories for manholes, handholes, pull boxes, and other utility structures.
  - d. Warning tape.
  - e. Warning planks.
2. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:
  - a. Duct entry provisions, including locations and duct sizes.
  - b. Reinforcement details.
  - c. Frame and cover design and manhole frame support rings.
  - d. Ladder **OR** Step, **as directed**, details.
  - e. Grounding details.
  - f. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
  - g. Joint details.
3. Shop Drawings for Factory-Fabricated Handholes and Pull Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:
  - a. Duct entry provisions, including locations and duct sizes.
  - b. Cover design.
  - c. Grounding details.
  - d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
4. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.
  - a. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
  - b. Drawings shall be signed and sealed by a qualified professional engineer.
5. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
6. Qualification Data: For qualified professional engineer and testing agency.
7. Source quality-control reports
8. Field quality-control test reports.



- E. Quality Assurance
  - 1. Comply with IEEE C2.
  - 2. Comply with NFPA 70.
- F. Delivery, Storage, And Handling
  - 1. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.
  - 2. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.
  - 3. Lift and support precast concrete units only at designated lifting or supporting points.
- G. Project Conditions
  - 1. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
    - a. Notify the Owner no fewer than two days in advance of proposed interruption of electrical service.
    - b. Do not proceed with interruption of electrical service without the Owner's written permission.

## 1.2 PRODUCTS

- A. Conduit
  - 1. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.
  - 2. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.
- B. Nonmetallic Ducts And Duct Accessories
  - 1. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type EB-20-PVC, ASTM F 512, UL 651A, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
  - 2. Underground Plastic Utilities Duct: NEMA TC 6 & 8, Type DB-60-PVC and Type DB-120-PVC, ASTM F 512, with matching fittings by the same manufacturer as the duct, complying with NEMA TC 9.
  - 3. Duct Accessories:
    - a. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and sizes of ducts with which used, and selected to provide minimum duct spacings indicated while supporting ducts during concreting or backfilling.
    - b. Warning Tape: Underground-line warning tape specified in Division 26 Section "Identification For Electrical Systems".
    - c. Concrete Warning Planks: Nominal 12 by 24 by 3 inches (300 by 600 by 76 mm) in size, manufactured from 6000-psi (41-MPa) concrete.
      - 1) Color: Red dye added to concrete during batching.
      - 2) Mark each plank with "ELECTRIC" in 2-inch- (50-mm-) high, 3/8-inch- (10-mm-) deep letters.
- C. Precast Concrete Handholes And Pull Boxes
  - 1. Comply with ASTM C 858 for design and manufacturing processes.
  - 2. Ferrous metal hardware shall be hot-dip galvanized in accordance with ASTM A153 (ASTM A153M) and ASTM A123 (ASTM A123M).
  - 3. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or pull box.

- a. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- b. Frame and Cover: Weatherproof steel frame, with steel cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
- c. Frame and Cover: Weatherproof steel frame, with hinged steel access door assembly with tamper-resistant, captive, cover-securing bolts.
  - 1) Cover Hinges: Concealed, with hold-open ratchet assembly.
  - 2) Cover Handle: Recessed.
- d. Frame and Cover: Weatherproof aluminum frame with hinged aluminum access door assembly with tamper-resistant, captive, cover-securing stainless-steel bolts.
  - 1) Cover Hinges: Concealed, with hold-open ratchet assembly.
  - 2) Cover Handle: Recessed.
- e. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
- f. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** As indicated for each service, **as directed**.
- g. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed**, bottom, unless otherwise indicated.
- h. Extensions and Slabs: Designed to mate with bottom of enclosure. Same material as enclosure.
  - 1) Extension shall provide increased depth of **12 inches (300 mm)**.
  - 2) Slab: Same dimensions as bottom of enclosure, and arranged to provide closure.
- i. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional **12 inches (300 mm)** vertically and horizontally to accommodate alignment variations.
  - 1) Windows shall be located no less than **6 inches (150 mm)** from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
  - 2) Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
  - 3) Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
- j. Duct Entrances in Handhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
  - 1) Type and size shall match fittings to duct or conduit to be terminated.
  - 2) Fittings shall align with elevations of approaching ducts and be located near interior corners of handholes to facilitate racking of cable.
- k. Handholes **12 inches wide by 24 inches long (300 mm wide by 600 mm long)** and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

D. Handholes and Pull Boxes Other Than Precast Concrete

1. Description: Comply with SCTE 77.
  - a. Color: Gray **OR** Green, **as directed**.
  - b. Configuration: Units shall be designed for flush burial and have open **OR** closed **OR** integral closed, **as directed**, bottom, unless otherwise indicated.
  - c. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
  - d. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
  - e. Cover Legend: Molded lettering, "ELECTRIC" **OR** "TELEPHONE" **OR** As indicated for each service, **as directed**.
  - f. Direct-Buried Wiring Entrance Provisions: Knockouts equipped with insulated bushings or end-bell fittings, selected to suit box material, sized for wiring indicated, and arranged for secure, fixed installation in enclosure wall.
  - g. Duct Entrance Provisions: Duct-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
  - h. Handholes **12 inches wide by 24 inches long (300 mm wide by 600 mm long)** and larger shall have factory-installed inserts for cable racks and pulling-in irons.

2. Polymer Concrete Handholes and Pull Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
3. Fiberglass Handholes and Pull Boxes with Polymer Concrete Frame and Cover: Sheet-molded, fiberglass-reinforced, polyester resin enclosure joined to polymer concrete top ring or frame.
4. Fiberglass Handholes and Pull Boxes: Molded of fiberglass-reinforced polyester resin, with covers of polymer concrete **OR** reinforced concrete **OR** cast iron **OR** hot-dip galvanized-steel diamond plate **OR** fiberglass, **as directed**.
5. High-Density Plastic Pull Boxes: Injection molded of high-density polyethylene or copolymer-polypropylene. Cover shall be polymer concrete **OR** hot-dip galvanized-steel diamond plate **OR** plastic, **as directed**.

E. Precast Manholes

1. Comply with ASTM C 858, with structural design loading as specified in Para. 1.3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.
  - a. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks plus an additional **12 inches (300 mm)** vertically and horizontally to accommodate alignment variations.
    - 1) Windows shall be located no less than **6 inches (150 mm)** from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
    - 2) Window opening shall have cast-in-place, welded wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
    - 3) Window openings shall be framed with at least two additional No. 4 steel reinforcing bars in concrete around each opening.
  - b. Duct Entrances in Manhole Walls: Cast end-bell or duct-terminating fitting in wall for each entering duct.
    - 1) Type and size shall match fittings to duct or conduit to be terminated.
    - 2) Fittings shall align with elevations of approaching ducts and be located near interior corners of manholes to facilitate racking of cable.
2. Concrete Knockout Panels: **1-1/2 to 2 inches (38 to 50 mm)** thick, for future conduit entrance and sleeve for ground rod.
3. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

F. Cast-In-Place Manholes

1. Description: Underground utility structures, constructed in place, complete with accessories, hardware, and features. Include concrete knockout panels for conduit entrance and sleeve for ground rod.
2. Materials: Comply with ASTM C 858 and with Division 03 Section "Cast-in-place Concrete".
  - a. Concrete shall have a minimum compressive strength of **3000 psi (20 MPa)**.
3. Structural Design Loading: As specified in "Underground Enclosure Application" Article.

G. Utility Structure Accessories

1. Ferrous metal hardware, where indicated, shall be hot-dip galvanized complying with ASTM **A 153 (A 153M)** and **A 123 (A 123M)**.
2. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
  - a. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B **OR** cast aluminum, **as directed**, with milled cover-to-frame bearing surfaces; diameter, **26 inches (660 mm) OR 29 inches (737 mm)**, **as directed**.
    - 1) Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.

- 2) Special Covers: Recess in face of cover designed to accept finish material in paved areas.
- b. Cover Legend: Cast in. Selected to suit system.
  - 1) Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
  - 2) Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
  - 3) Legend: "SIGNAL" for communications, data, and telephone duct systems.
- c. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
  - 1) Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
3. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
4. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.
  - a. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
5. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (32-mm-) diameter eye, rated 2500-lbf (11-kN) minimum tension.
6. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
  - a. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
7. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (32 mm) minimum at base.
  - a. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
8. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.
9. Cable Rack Assembly: Steel, hot-rolled **OR** hot-dip, **as directed**, galvanized, except insulators.
  - a. Stanchions: T-section or channel; 2-1/4-inch (57-mm) nominal size; punched with 14 holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
  - b. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (460 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
  - c. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.
10. Cable Rack Assembly: Nonmetallic. Components fabricated from nonconductive, fiberglass-reinforced polymer.
  - a. Stanchions: Nominal 36 inches (900 mm) high by 4 inches (100 mm) wide, with minimum of 9 holes for arm attachment.
  - b. Arms: Arranged for secure, drop-in attachment in horizontal position at any location on cable stanchions, and capable of being locked in position. Arms shall be available in lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 20 inches (508 mm) with 250-lb (114-kg) minimum capacity. Top of arm shall be nominally 4 inches (100 mm) wide, and arm shall have slots along full length for cable ties.
11. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.
12. Fixed Manhole Ladders: Arranged for attachment to roof or wall **OR** and floor, **as directed**, of manhole. Ladder and mounting brackets and braces shall be fabricated from nonconductive, structural-grade, fiberglass-reinforced resin **OR** hot-dip galvanized steel, **as directed**.



13. Portable Manhole Ladders: UL-listed, heavy-duty wood **OR** fiberglass, **as directed**, specifically designed for portable use for access to electrical manholes. Minimum length equal to distance from deepest manhole floor to grade plus **36 inches (900 mm)**. One required.
14. Cover Hooks: Heavy duty, designed for lifts **60 lbf (270 N)** and greater **OR** Light duty, designed for lifts less than **60 lbf (270 N)**, **as directed**. Two required.

H. Source Quality Control

1. Test and inspect precast concrete utility structures according to ASTM C 1037.
2. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of manholes and pull boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
  - a. Engage a qualified testing agency to evaluate nonconcrete handholes and pull boxes.
  - b. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

### 1.3 EXECUTION

A. Corrosion Protection

1. Aluminum shall not be installed in contact with earth or concrete.

B. Underground Duct Application

1. Ducts for Electrical Cables Over 600 V: RNC, NEMA Type EPC-80 **OR** EPC-40 **OR** EB-20, **as directed**, PVC, in concrete-encased duct bank, unless otherwise indicated.
2. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 **OR** EPC-40 **OR** EB-20, **as directed**, PVC, in concrete-encased duct bank, unless otherwise indicated.
3. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 **OR** EPC-40 **as directed**, PVC, in direct-buried duct bank, unless otherwise indicated.
4. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-80 **OR** EPC-40, **as directed**, PVC, in direct-buried duct bank, unless otherwise indicated.
5. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40 **OR** EB-20, **as directed**, PVC, in concrete-encased duct bank, unless otherwise indicated.
6. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC **OR** Underground plastic utilities duct, NEMA Type DB-60-PVC **OR** Underground plastic utilities duct, NEMA Type DB-120-PVC, **as directed**, installed in direct-buried **OR** concrete-encased, **as directed**, duct bank, unless otherwise indicated.
7. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EPC-40 **OR** DB-60 **OR** DB-120, **as directed**, PVC, in direct-buried duct bank, unless otherwise indicated.
8. Underground Ducts for Telephone, Communications, or Data Circuits: RNC, NEMA Type EB-20-PVC, in concrete-encased duct bank, unless otherwise indicated.
9. Underground Ducts Crossing Paved Paths **OR** Walks and Driveways **OR** Roadways and Railroads, **as directed**: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

C. Underground Enclosure Application

1. Handholes and Pull Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:
  - a. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete, AASHTO HB 17, H-10 **OR** H-20, **as directed**, structural load rating.
  - b. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Precast concrete, AASHTO HB 17, H-20 **OR** Polymer concrete, SCTE 77, Tier 15 **OR** Fiberglass enclosures with polymer concrete frame and cover, SCTE 77, Tier 15 **OR** Fiberglass-reinforced polyester resin, SCTE 77, Tier 15 **OR** High-density plastic, SCTE 77, Tier 15, **as directed**, structural load rating.



- c. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Precast concrete, AASHTO HB 17, H-10 **OR** Polymer concrete units, SCTE 77, Tier 8 **OR** Heavy-duty fiberglass units with polymer concrete frame and cover, SCTE 77, Tier 8 **OR** High-density plastic, SCTE 77, Tier 8, **as directed**, structural load rating.
    - d. Units Subject to Light-Duty Pedestrian Traffic Only: Fiberglass-reinforced polyester resin **OR** High-density plastic, **as directed**, structurally tested according to SCTE 77 with **3000-lbf (13 345-N)** vertical loading.
  2. Manholes: Precast or cast-in-place concrete.
    - a. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
    - b. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.
- D. Earthwork
  1. Excavation and Backfill: Comply with Division 31 Section "Earth Moving", but do not use heavy-duty, hydraulic-operated, compaction equipment.
  2. Restore surface features at areas disturbed by excavation and reestablish original grades, unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
  3. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32 Section(s) "Turf And Grasses" AND "Plants".
  4. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01 Section "Cutting And Patching".
- E. Duct Installation
  1. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes to drain in both directions.
  2. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep bends with a minimum radius of **48 inches (1220 mm) OR 12.5 feet (4 m) OR 25 feet (7.5 m)**, **as directed**, both horizontally and vertically, at other locations, unless otherwise indicated.
  3. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
  4. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately **10 inches (250 mm)** o.c. for **5-inch (125-mm)** ducts, and vary proportionately for other duct sizes.
    - a. Begin change from regular spacing to end-bell spacing **10 feet (3 m)** from the end bell without reducing duct line slope and without forming a trap in the line.
    - b. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole.
    - c. Grout end bells into structure walls from both sides to provide watertight entrances.
  5. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least **10 feet (3 m)** outside the building wall without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Division 26 Section "Common Work Results For Electrical".
  6. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least **15-psig (1.03-MPa)** hydrostatic pressure.
  7. Pulling Cord: Install **100-lbf- (445-N-)** test nylon cord in ducts, including spares.
  8. Concrete-Encased Ducts: Support ducts on duct separators.
    - a. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than **4 OR 5**, **as directed**, spacers per **20 feet (6 m)** of duct. Secure

- separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately **6 inches (150 mm)** between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
- b. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
    - 1) Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.
    - 2) If more than one pour is necessary, terminate each pour in a vertical plane and install **3/4-inch (19-mm)** reinforcing rod dowels extending **18 inches (450 mm)** into concrete on both sides of joint near corners of envelope.
  - c. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
  - d. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
  - e. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
  - f. Minimum Space between Ducts: **3 inches (75 mm)** between ducts and exterior envelope wall, **2 inches (50 mm)** between ducts for like services, and **4 inches (100 mm)** between power and signal ducts.
  - g. Depth: Install top of duct bank at least **24 inches (600 mm)** below finished grade in areas not subject to deliberate traffic, and at least **30 inches (750 mm)** below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
  - h. Stub-Ups:
    - 1) Use manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Extend concrete encasement throughout the length of the elbow.  
**OR**  
Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
      - a) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with **3 inches (75 mm)** of concrete.
      - b) Stub-Ups to Equipment: For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of **60 inches (1500 mm)** from edge of base. Install insulated grounding bushings on terminations at equipment.
  - i. Warning Tape: Bury warning tape approximately **12 inches (300 mm)** above all concrete-encased ducts and duct banks. Align tape parallel to and within **3 inches (75 mm)** of the centerline of duct bank. Provide an additional warning tape for each **12-inch (300-mm)** increment of duct-bank width over a nominal **18 inches (450 mm)**. Space additional tapes **12 inches (300 mm)** apart, horizontally.
9. Direct-Buried Duct Banks:
- a. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
  - b. Space separators close enough to prevent sagging and deforming of ducts, with not less than **4 OR 5, as directed**, spacers per **20 feet (6 m)** of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement

due to expansion and contraction as temperature changes. Stagger spacers approximately **6 inches (150 mm)** between tiers.

- c. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 Section "Earth Moving" for pipes less than **6 inches (150 mm)** in nominal diameter.
- d. Install backfill as specified in Division 31 Section "Earth Moving".
- e. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to **4 inches (100 mm)** over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving".
- f. Install ducts with a minimum of **3 inches (75 mm)** between ducts for like services and **6 inches (150 mm)** between power and signal ducts.
- g. Depth: Install top of duct bank at least **36 inches (900 mm)** below finished grade, unless otherwise indicated.
- h. Set elevation of bottom of duct bank below the frost line.
- i. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.

**OR**

Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

- 1) Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with **3 inches (75 mm)** of concrete.
- 2) For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of **60 inches (1500 mm)** from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.
- j. Warning Planks: Bury warning planks approximately **12 inches (300 mm)** above direct-buried ducts and duct banks, placing them **24 inches (600 mm)** o.c. Align planks along the width and along the centerline of duct bank. Provide an additional plank for each **12-inch (300-mm)** increment of duct-bank width over a nominal **18 inches (450 mm)**. Space additional planks **12 inches (300 mm)** apart, horizontally.

**F. Installation Of Concrete Manholes, Handholes, And Pull Boxes**

1. Cast-in-Place Manhole Installation:
  - a. Finish interior surfaces with a smooth-troweled finish.
  - b. Windows for Future Duct Connections: Form and pour concrete knockout panels **1-1/2 to 2 inches (38 to 50 mm)** thick, arranged as indicated.
  - c. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03 Section "Cast-in-place Concrete".
2. Precast Concrete Handhole and Manhole Installation:
  - a. Comply with ASTM C 891, unless otherwise indicated.
  - b. Install units level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances.
  - c. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from **1-inch (25-mm)** sieve to **No. 4 (4.75-mm)** sieve and compacted to same density as adjacent undisturbed earth.
3. Elevations:
  - a. Manhole Roof: Install with rooftop at least **15 inches (380 mm)** below finished grade.
  - b. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames **1 inch (25 mm)** above finished grade.
  - c. Install handholes with bottom below the frost line, below grade.



- d. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes **1 inch (25 mm)** above finished grade.
  - e. Where indicated, cast handhole cover frame integrally with handhole structure.
  4. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
  5. Manhole Access: Circular opening in manhole roof; sized to match cover size.
    - a. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
    - b. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.
  6. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07 Section(s) "Elastomeric Sheet Waterproofing" OR "Thermoplastic Sheet Waterproofing", **as directed**. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
  7. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Division 07 Section "Bituminous Dampproofing". After ducts have been connected and grouted, and before backfilling, dampproof joints and connections and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
  8. Hardware: Install removable hardware, including pulling eyes, cable stanchions, and cable arms, and insulators, as required for installation and support of cables and conductors and as indicated.
  9. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.
  10. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than **3-7/8 inches (98 mm)** for manholes and **2 inches (50 mm)** for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.
  11. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.
- G. Installation Of Handholes And Pull Boxes Other Than Precast Concrete
1. Install handholes and pull boxes level and plumb and with orientation and depth coordinated with connecting ducts to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by the manufacturer.
  2. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from **1/2-inch (12.7-mm)** sieve to **No. 4 (4.75-mm)** sieve and compacted to same density as adjacent undisturbed earth.
  3. Elevation: In paved areas and trafficways, set so cover surface will be flush with finished grade. Set covers of other handholes **1 inch (25 mm)** above finished grade.
  4. Install handholes and pull boxes with bottom below the frost line, below grade.
  5. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in the enclosure.
  6. Field-cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
  7. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.
    - a. Concrete: **3000 psi (20 kPa)**, 28-day strength, complying with Division 03 Section "Cast-in-place Concrete", with a troweled finish.

- b. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).
- H. Grounding
  - 1. Ground underground ducts and utility structures according to Division 26 Section "Grounding And Bonding For Electrical Systems".
- I. Field Quality Control
  - 1. Perform the following tests and inspections:
    - a. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
    - b. Pull aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
    - c. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Division 26 Section "Grounding And Bonding For Electrical Systems".
  - 2. Correct deficiencies and retest as specified above to demonstrate compliance.
  - 3. Prepare test and inspection reports.
- J. Cleaning
  - 1. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
  - 2. Clean internal surfaces of manholes, including sump. Remove foreign material.

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Task	Specification	Specification Description
33 01 30 81	01 22 16 00	No Specification Required
33 01 30 81	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 81	22 05 76 00	Sanitary Sewerage
33 01 30 81	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 81	33 42 11 00	Storm Drainage
33 01 30 81	31 32 19 16	Sewage Treatment Lagoons
33 01 30 82	01 22 16 00	No Specification Required
33 01 30 83	01 22 16 00	No Specification Required
33 01 30 83	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 83	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 83	33 01 30 81	Repair And Maintenance Of Siphon Tank And Siphons
33 01 30 86	01 22 16 00	No Specification Required
33 01 30 86	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 30 86	33 01 10 58	Repair And Maintenance Of Imhoff Tanks
33 01 30 86	33 01 30 81	Repair And Maintenance Of Siphon Tank And Siphons
33 01 34 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 01 34 13	33 01 30 81	Repair And Maintenance Of Siphon Tank And Siphons

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## SECTION 33 05 07 13 - TRENCHLESS EXCAVATION USING MICROTUNNELING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of trenchless excavation using microtunneling. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Design Requirements

1. Pipe Casing: Provide pipe casing in thickness indicated of polyvinyl chloride (PVC) plastic **OR** clay tile **OR** concrete **OR** steel, **as directed**, pipe. Provide utility line accessories, valves, connections, and manholes as specified and where indicated. Submit design calculations of pipe casing.

#### C. Submittals: Submit the following:

1. Preconstruction Submittals: Microtunneling Boring Machine equipment to be used.
2. Product Data
  - a. Piping casing, joints, fittings, valves, and couplings
  - b. Bentonite
  - c. Submit manufacturer's standard drawings or catalog cuts, except submit both drawings and cuts for push-on and rubber-gasketed bell-and-spigot joints. Include information concerning gaskets with submittal for joints and couplings.
3. Design Data: Design calculations of pipe casing
4. Certificates
  - a. Piping casing piping, fittings, joints, valves, and coupling
  - b. Shop-applied linings
  - c. Certificates shall attest that tests set forth in each applicable referenced publication have been performed, whether specified in that publication to be mandatory or otherwise and that production control tests have been performed at the intervals or frequency specified in the publication. Other tests shall have been performed within 3 years of the date of submittal or certificates on the same type, class, grade, and size of material as is being provided for the project.
5. Manufacturer's Instructions: Installation procedures for pipe casing

#### D. Delivery, Storage, and Handling:

1. Inspect materials delivered to site for damage. Unload and store with minimum handling. Store materials on site in enclosures or under protective covering. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight. Do not store materials directly on the ground. Keep inside of pipes, fittings, and valves free of dirt and debris.
2. Handle pipe, fittings, valves, hydrants, and other accessories in a manner to ensure delivery to the excavation in sound undamaged condition. Take special care to avoid injury to coatings and linings on pipe and fittings; make satisfactory repairs if coatings or linings are damaged. Carry, do not drag pipe to the excavation. Store plastic piping, jointing materials and rubber gaskets that are not to be installed immediately, under cover out of direct sunlight. Handle steel pipe with coal-tar enamel **OR** coal-tar epoxy, **as directed**, coating in accordance with the provisions for handling coal-tar enamel coated pipe in AWWA C203.

#### E. Quality Assurance

1. Design Calculations of Pipe Casing: Submit design calculations of pipe casing demonstrating that the pipe casing selected has been designed to support the maximum anticipated earth loads and superimposed live loads, both static and dynamic, which may be imposed on the pipe casing.

## 1.2 PRODUCTS

### A. Piping Casing Materials

#### 1. Ductile-Iron Piping

- a. Pipe and Fittings: Pipe, except flanged pipe, ANSI/AWWA C151/A21.51 Pressure Class and/or Thickness Class as required to meet Project requirements. The outside diameter of ductile iron microtunneling pipe shall be in accordance with AWWA C150/A21.50.
- b. Joints and Jointing Material: Joints: Pressure and gravity microtunneling pipe shall have either an integral-bell push-on or rubber gasket coupled joint meeting the following criteria:
  - 1) Integral-bell push-on joint microtunneling pipe shall consist of a rubber-gasket joint manufactured to conform with AWWA C111/A21.11 and the dimensions shown in ANSI/AWWA C151/A21.51. The exterior of the pipe shall be coated with a durable cement-mortar or concrete coating applied in such a manner as to provide a uniform outside diameter.
  - 2) Cement-mortar or concrete strength, reinforcement and method of placement shall be in accordance with manufacturer's recommendations. Durable Coatings of other types may be substituted provided they maintain a uniform outside diameter and they are approved by the designer. Rubber gasket coupled microtunneling joint shall be manufactured so as to provide a joint which has the same nominal outside diameter as the pipe barrel.

#### 2. Polyvinyl Chloride Pipe (PVC): ASTM F 794. ASTM D 3212 for gasketed joint systems. ASTM F 477 for gasket materials.

#### 3. Reinforced Concrete Pipe

- a. Nominal dimensions: Typical nominal dimensions for reinforced concrete pipe are detailed in ASTM standards **ASTM C 76 (ASTM C 76M)**, **ASTM C 361 (ASTM C361M)**, **ASTM C 655 (ASTM C 655M)**, **ASTM C 822**. Pipe meeting these requirements is generally acceptable for jacking. The permissible variation allowed with respect to these and other dimensions shall be in accordance with the variations listed in the section.
- b. Joints and Jointing Material: Joint shall be formed entirely of concrete and as detailed in the contract drawings, may **OR** shall, **as directed**, utilize a rubber gasket or mastic to provide the seal. Incorporate an assembly of steel bands or steel bell ends and spigot rings and rubber gaskets in accordance with contract drawings.

#### 4. Steel Pipe

- a. Steel pipe shall be in conformance with ASTM A 139, Grade B with a minimum yield strength of **35,000 psi (242 MPa)** **OR** AWWA C200 **OR** API SPEC 5L Grade B **OR** ASTM A 53 **OR** ASTM A 716 **OR** ASTM A 746, **as directed**. Steel pipe shall be welded, seamless, square cut with even lengths and shall comply of Articles 4.2, 4.3, and 4.4 of the API SPEC 5L.
- b. Joints: The connection of adjacent pieces of microtunneling steel pipe may be accomplished by field butt welding, internal weld sleeves, integral press fit connectors, as long as loading and installation design criteria are met.

#### 5. Fiberglass Pipe

- a. Pipe: Fiberglass pipe shall meet the requirements of ASTM D 3262, Type 1, Liner 2, Grade 3. The method of the manufacture shall be centrifugal casting resulting in a controlled outside diameter. Minimum wall thickness shall be **+1.5 inches (+38 mm)**.
- b. Joints: The pipes shall be connected by gasket-sealed bell-spigot joints. The gasket material shall meet requirements of ASTM F 477. The joint shall meet the requirements of ASTM D 4161 and shall be leak-free under the following conditions:
  - 1) External pressures up to 2 bars, **29 psi (200 kPa)** from bentonite injection, slurry system operation or groundwater head.
  - 2) Internal air testing up to **5 psi (35 kPa)**.
  - 3) Gaps between the pipe ends up to two percent of the diameter (maximum of **1-inch (25 mm)**).

- c. The liner shall consist of a minimum thickness of **0.04 inch (1.2 mm)** of reinforced polyester resin. The outside pipe coating shall have a minimum thickness of **0.03 inches (one mm)** and shall consist of thermosetting polyester resin and sand.
- 6. Vitrified Clay Pipe: ASTM C 700.
  - a. Pipe: Vitrified clay pipe shall be manufactured from fire clay, shale, surface clay, or a combination that can meet three edge bearing strength for nominal diameters ranging from **4 inches 2000 lb/linear foot (100 mm 2980 kg/m)** to **42 inches 7000 lb/linear foot (1050 mm 10430 kg/m)**.
  - b. Joints: Joints shall be capable of supporting a shear load of **50 pounds per inch (8755 N/m)** of nominal diameter uniformly applied over an arc of not less than **120 degrees (2.09 rad)** and along a distance of **12 inches (300 mm)** adjacent to the joint. Apply an internal **10 foot (3 m) head 4.3 psi (30 kPa)** of water pressure for a period of one hour. Joints shall fully comply with **ASTM C 1208 (ASTM C 1208M)**.
- 7. Concrete: Concrete shall be **3000 psi (25 MPa)** and conform with Division 03 Section "Cast-in-place Concrete".
- 8. Bentonite: Bentonite shall conform with API SPEC 13A and have the capacity of mixing with water to form a stable and homogeneous suspension.
- 9. Backfill: Reuse excavated sand for backfill that conforms with Division 31 Section "Earth Moving".

### 1.3 EXECUTION

#### A. Preparation

##### 1. Access Shafts

- a. Construction methods required to provide access shafts for microtunneling shall be subject to approval of the Owner. Acceptable construction methods may include the use of interlocked steel sheet piling or precast circular concrete segments lowered in place during excavation.
- b. Final dimensions of access shafts selected by the Contractor shall be modified as required following installation of pipe casings to the size and shape of acceptable manhole designs shown on the Contract Drawings to permit installation of conveyance piping.
- c. Shafts shall be of a size commensurate with safe working practices and located as shown on plans. With the approval of the Owner, the Contractor may relocate shafts to better suit the capabilities of the microtunneling method proposed. Where no locations are given, the Contractor shall determine such.
- d. Shaft locations shall, where possible, be kept clear of road intersections and within a single traffic lane, in order to minimize disruption to the flow of traffic. Support equipment, spoil piles, and materials shall also be located such as to minimize disruption to traffic and are subject to the approval of the Owner.
- e. The Contractor shall properly support all excavations and prevent movement of the soil, pavement, utilities or structures outside of the excavation. The Contractor shall furnish, place and maintain sheeting, bracing, and lining required to support the sides and floor of all pits and to provide adequate protection of the work, personnel, and the general public. Design loads on the sides of the jacking and receiving pit walls are dependent on the construction method and flexibility of the wall systems.
- f. Construct a starter shaft to accommodate the installation of pipe casings, slurry shield and piping jacking device. Install thrust block as required and consolidate the ground (grout) where the casings exit the shaft.
- g. Construct a receiver shaft to accommodate the installation of pipe casings and the slurry shield. Consolidate the ground (grout) where the casings enter the shaft.
- h. The Contractor shall furnish, install, and maintain equipment to keep the jacking shaft free of excess water. The Contractor shall also provide surface protection during the period of construction to ensure that surface runoff does not enter driving shaft(s). Groundwater dewatering shall comply with the approved dewatering plan and shall not affect



surrounding soils or structures beyond the tolerances stated in paragraph entitled "Settlement, Alignment and Tolerances."

- i. Provide security fence around all access shaft areas and provide shaft cover(s) when the shaft area is not in use.
- j. Design of the jacking and receiving pit supports should also take into account the loading from shield or pipe jacking where appropriate, as well as special provisions and reinforcement around the breakout location. The base of the pits shall be designed to withstand uplift forces from the full design head of water, unless approved dewatering or other ground modification methods are employed.
- k. Where a thrust block is required to transfer jacking loads into the soil, it shall be properly designed and constructed by the Contractor. The backstop shall be normal (square) with the proposed pipe alignment and shall be designed to withstand the maximum jacking pressure to be used with a factor of safety of at least 2.0. It shall also be designed to minimize excessive deflections in such a manner as to avoid disturbance of adjacent structures or utilities or excessive ground movement. If a concrete thrust block or treated soil zone is utilized to transfer jacking loads into the soil, the tunnel boring is not to be jacked until the concrete or other materials have attained the required strength.
- l. Pit Backfill and Compaction: Upon completion of the pipe drive and approval of the installed pipeline by the Owner, remove all equipment, debris, and unacceptable materials from the pits and commence backfilling operation. Backfilling, compaction and pavement repairs shall be completed in accordance with Division 31 Section "Earth Moving".
- m. If tremie concrete sealing slabs are placed within the earth support system to prevent groundwater inflow when access shafts are dewatered, the sealing slabs shall be of sufficient thickness to provide a factor of safety equal to 1.2 against hydrostatic uplift in order to prevent bottom blowout when the excavation is completely dewatered.

#### B. Installation

- 1. Installation of Tracer Wire: Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe. Attach wire to top of pipe in such a manner that will not be displaced during construction operations.
- 2. Connections to Existing Lines: Make connections to existing lines after the Owner approval is obtained and with a minimum interruption of service on the existing line. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped.
- 3. Minimum depth of cover over the pipe being installed shall be **6 feet (1.8 m)** or 1.5 times the outer diameter of the pipe being installed.
- 4. Settlement, Alignment and Tolerances
  - a. Settlement or heave of ground surface along centerline of microtunneling alignments during and after installation of pipe casings shall not exceed **1 inch (25 mm)**.
  - b. No more than **1 inch (25 mm)** lateral and **1 inch (25 mm)** vertical deviation shall be permitted in the position of the completed jacked pipe casings. Water shall be free draining between any two points at the pipe invert. No reverse grades will be allowed.
  - c. Overcut shall not exceed **1 inch (25 mm)** on the radius of the pipe being installed. The annular space created by the overcut must be filled with the lubrication material that is used to reduce soil friction drag on the pipe.
- 5. Microtunneling
  - a. Using Unmanned Tunneling Machine
    - 1) The microtunneling boring machine shall be an unmanned mechanical type earth pressure counter-balanced bentonite slurry shield system. The machine shall be laser guided and monitored continuously, with a closed circuit television system. The machine shall be capable of fully supporting the face both during excavation and during shutdown and shall have the capability, of positively measuring the earth pressure at the face. Excavation face pressure shall be maintained at all times between the measured active earth pressure and 50 percent of the computed passive earth pressure. Fluid pressure applied at the face to stabilize the

- excavation shall be maintained at a level slightly in excess of normal hydrostatic pressure and shall be monitored continuously. The machine shall be operated so as to prevent either surface heave or loss of ground during tunneling and shall be steerable and capable of controlling the advance of the heading to maintain line and grade within the tolerances specified in paragraph entitled "Settlement, Alignment and Tolerances." The machine shall be capable of handling and removing materials of high water content from the machine head.
- 2) Each pipe casing section shall be jacked forward as the excavation progresses in such a way to provide complete and adequate, ground support at all times. A bentonite slurry (driller's mud) shall be applied to the external surface of the pipe to reduce skin friction. A jacking frame shall be provided for developing a uniform distribution of jacking forces around the periphery of the pipe. A plywood spacer shall be placed on the outer shoulder of the pipe casing joint. The thrust reaction backstop shall be properly designed and constructed.
  - 3) The backstop shall be normal (square) with the proposed pipe casing alignment and shall be designed to support the maximum obtainable jacking pressure with a safety factor at least 2.0.
  - 4) The jacking system shall be capable of continuously monitoring the jacking pressure and rate of advancement. Special care shall be taken when setting the pipe guard rails in the starter shaft to ensure correctness of the alignment, grade and stability.
- b. Using Tunneling Shields
- 1) Only tunneling equipment capable of fully supporting the face of the tunnel shall be used for pipe jacking work described.
  - 2) Tunneling equipment selected for the project shall be compatible with the geotechnical information contained in this contract. The tunneling equipment shall be capable of tunneling through mixed face conditions without exceeding the settlement tolerances specified in paragraph "Settlement, Alignment and Tolerances."
  - 3) Face pressure exerted at the heading by the tunneling machine shall be maintained as required to prevent loss of ground, groundwater inflows, and settlement or heave of the ground surface by balancing soils and groundwater pressures present.
  - 4) Dewatering for groundwater control shall be allowed at the jacking and receiving pits only.
- c. Do not jack pipe casing until the concrete thrust block and tremie seal (if selected), and grouted soil zone in starter and receiving shafts have attained the required strength.
- d. The pipe casing shall be jacked in place without damaging the pipe casing joints or completed pipe casing section.
- e. After completion of the jacking operation between starter and receiver shafts, the lubricate material shall be displaced from between the pipe casing exterior and the surrounding ground by a cement grout. Pressure and the amount of grout shall be controlled to avoid pipe damage and displacement of the pipe and soil beyond the tolerances specified in paragraph "Settlement, Alignment and Tolerances." Grouting shall be accomplished promptly after pipe installation has been completed to prevent any surface settlement due to movement of soil material into the void space or loosened zone around the pipe casing.
- f. Any pipe casing which has been damaged during installation shall be replaced by the Contractor at no additional cost. If a new replacement pipe casing is required extending from the starter to the receiver shaft, it shall be installed in conformance with the contract drawings and this section.
- g. Steel pipe casing joints shall be continuously welded with butt joint per AWS D1.1. The welds shall attain the full strength of the pipe and shall result in a full watertight section. The inner face of internal weld seam shall be flush with the pipe to facilitate the installation of the conveyance pipe in the pipe casing.
- h. Perform all welding in accordance with requirements for shielded metal arc welding of AWS D1.5 for bridges and AWS D1.1 for buildings and other structures.
- i. Fiberglass pipe casing joints shall be fully watertight and shall attain the full strength of the pipe. Casing joints shall be field connected with sleeve couplings or bell and spigot type

- joints that utilize elastomeric sealing gaskets as the sole means to maintain joint water tightness.
- j. The joint shall have the same outside diameter as the pipe so when the pipelines are assembled such that the joints are flush with the pipe inside and outside surface to facilitate installation of it conveyance pipe in the pipe casing.
  - k. All excavated material from tunnel and shaft construction shall be disposed of away from the construction site. On-site storage of material must comply with Division 01 requirements and must be stored in areas shown on site drawings or as directed. Stockpiling shall be permitted on the construction site and material shall be removed at regular intervals as directed by the Owner.
  - l. Monitor ground movements associated with the project and make suitable changes in the construction methods that control ground movements and prevent damage or detrimental movement to the work and adjacent structures and pavements.
  - m. Install instrumentation, take readings and provide the Owner with weekly reports containing measurements data with weekly reports to inspector. These actions are meant to supplement the Contractor's monitoring system and do not relieve the Contractor of its responsibility, nor place on the Owner, responsibility for control of ground movement and protection of the project and adjacent structures. Instrumentation readings shall be continued for a period of time as directed by the Owner after pipe casings have been installed to establish that detrimental settlement has not occurred.
  - n. Unprotected mining of the tunnel bore is not permitted. The tunnel face and bore shall be fully supported at all times.
  - o. A topographic survey will be performed by the Contractor before and after microtunneling and at intervals as directed by the Owner. Survey markers will be installed by the contractor at grid points located as directed by the Owner centered on the proposed tunnel alignments. Perform all remedial work including repaired if heave or settlement greater than **1 inch (25 mm)** is recorded.
  - p. Approval by the Owner of the topographic survey and final set of readings provided by the Contractor will constitute partial approval of the microtunneling phase of work.
- 6. Ventilation: Adequate ventilation shall be provided for all cased tunnels and shafts. Follow confined space entry procedures. Local burn permit regulations must be obeyed and complied with. The design of ventilating system shall include such factors as the volume required to furnish fresh air in the shafts, and the volume to remove dust that may be caused by the cutting of the face and other operations which may impact the laser guidance system.
  - 7. Lighting: Adequate lighting shall be provided for the nature of the activity being conducted by workers for the microtunneling. Both power and lighting circuits shall be separated and thoroughly insulated with ground fault interrupters are required. Lights shall comply with requirements with regards to shatter resistance and illumination requirements.
  - 8. Spoil Transportation: The soil transportation system shall match the excavation rate with rate of spoil removal. The system must also be capable of balancing groundwater pressures and adjustment to maintain face stability for the particular soil conditions of this project.
  - 9. Pipe Jacking Equipment: The main jacking equipment installed must have a capacity greater than the anticipated jacking load. Intermediate jacking stations shall be provided by the Contractor when the total anticipated jacking force needed to complete the installation may exceed the capacity of the main jacks or the designed maximum jacking force for the pipe. The jacking system shall develop a uniform distribution of jacking forces on the end of the pipe by use of thruster rings and cushioning material.
  - 10. Jacking Pipe: In general, pipe used for jacking shall be smooth, round, have an even outer surface, and joints that allow for easy connections between pipes. Pipe ends shall be square and smooth so that jacking loads are minimized when the pipe is jacking. Pipe used for pipe jacking shall be capable of withstanding the jacking forces that will be imposed by the process or installation, as well as the final place loading conditions. The driving ends of the pipe and intermediate joints shall be protected from damage.

- a. Any pipe showing signs of failure may be jacked through to the receiving shaft and removed. Other methods of repairing the damaged pipe may be used, as recommended by the manufacturer and subject to approval by the Owner.
  - b. The pipe manufacturer's design jacking loads shall not be exceeded during the installation process. The pipe shall be designed to take full account of all temporary installation loads.
- C. Field Quality Control
- 1. Field Tests and Inspections: The Contractor shall perform field tests, and provide labor, equipment, and incidentals required for testing. The Contractor shall produce evidence, when required, that any item of work has been constructed in accordance with drawings and specifications.
  - 2. Testing Requirements: For pressure test, use a hydrostatic pressure 50 percent greater than the maximum working pressure of the system. Hold this pressure for not less than 2 hours. For leakage test, use a hydrostatic pressure not less than the maximum working pressure of the system. Leakage test may be performed at the same time and at the same test pressure as the pressure test.

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Task	Specification	Specification Description
33 05 07 23	01 22 16 00	No Specification Required
33 05 07 23	33 05 07 13	Trenchless Excavation Using Microtunneling
33 05 07 24	33 05 07 13	Trenchless Excavation Using Microtunneling
33 05 61 00	22 05 76 00	Sanitary Sewerage
33 05 61 00	33 42 11 00	Storm Drainage
33 05 63 00	33 01 30 81a	Underground Ducts And Utility Structures
33 05 81 00	01 22 16 00	No Specification Required
33 05 81 00	22 05 76 00	Sanitary Sewerage
33 05 81 00	33 01 30 81a	Underground Ducts And Utility Structures
33 05 81 00	33 42 11 00	Storm Drainage
33 05 81 00	31 32 19 16	Sewage Treatment Lagoons
33 05 83 00	22 05 76 00	Sanitary Sewerage
33 05 83 00	33 01 30 81a	Underground Ducts And Utility Structures
33 05 83 00	33 42 11 00	Storm Drainage
33 05 83 00	31 32 19 16	Sewage Treatment Lagoons
33 05 84 00	01 22 16 00	No Specification Required
33 05 84 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 05 84 00	22 05 76 00	Sanitary Sewerage
33 05 84 00	33 42 11 00	Storm Drainage
33 05 84 00	31 32 19 16	Sewage Treatment Lagoons

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**SECTION 33 11 13 00 - WELL REPAIR**

1.1 GENERAL

A. Description Of Work

1. This specification covers the furnishing and installation of materials for repair and maintenance of water wells. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

B. Submittals

1. Product Data: For each type of product indicated.

1.2 PRODUCTS

- A. Repair and Replacement Parts shall be clean, free of rust and scale, and of proper size and design for the specific well repair to be made.

1.3 EXECUTION

- A. Cement Grout may be hand mixed at the site.
- B. Level and Re-Sod Area, after heavy equipment has been used or if chemicals have been spilled.
- C. Abandoned Wells shall be sealed in accordance with AWWA A100.
- D. Disinfect well, after repair, in accordance with AWWA A100.

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Task	Specification	Specification Description
33 11 13 00	01 22 16 00	No Specification Required
33 11 13 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 11 13 00	23 11 23 00a	Monitoring Wells
33 11 13 00	22 11 23 23	Water Supply Wells
33 14 00 00	13 12 13 00	Water Distribution
33 14 11 00	13 12 13 00	Water Distribution
33 14 13 00	13 12 13 00	Water Distribution
33 14 13 13	01 22 16 00	No Specification Required
33 14 13 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 13	31 62 16 19	Concrete-Filled Steel Piles
33 14 13 13	13 12 13 00	Water Distribution
33 14 13 13	22 05 76 00	Sanitary Sewerage
33 14 13 13	33 42 11 00	Storm Drainage

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## SECTION 33 14 13 23 - SAND DRAINS

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of sand drains. Products shall match existing materials and/or shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Submittals

1. Product Data: For each type of product indicated.

### 1.2 PRODUCTS

- A. Galvanized Perforated Corrugated Metal Pipe: AASHTO M36.
- B. Perforated Polyvinyl Chloride (PVC) Plastic Pipe: ASTM D 1784.
- C. Aggregate shall be sand, gravel, crushed rock, or chat that is clean, sound, and of a good quality. Gradation shall conform to the following table:

Retained on the 1-inch sieve	0%
Retained on the 3/8-inch sieve	0-15%
Retained on the No. 8 sieve	40-60%
Retained on the No. 30 sieve	70-95%
Retained on the No. 100 sieve	98-100%

### 1.3 EXECUTION

- A. Pipe Bedding: Aggregate shall be placed in uniform layers on level excavation.
- B. Perforated Pipe shall be installed with securely aligned joints to lines and grades, which will allow proper drainage.
- C. Perforated Pipe shall be embedded with a minimum coverage of two feet of aggregate or as directed.

END OF SECTION 33 14 13 23

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## SECTION 33 14 13 23a - HYDRONIC DISTRIBUTION

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for hydronic distribution. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes underground piping outside the building for distribution of heating hot and chilled water.

#### C. Performance Requirements

1. Provide components and installation capable of producing hydronic piping systems with the following minimum working-pressure ratings:
  - a. Hot-Water Piping: 100 psig (690 kPa) OR 150 psig (1035 kPa), as directed.
  - b. Chilled-Water Piping: 100 psig (690 kPa) OR 150 psig (1035 kPa), as directed.
  - c. Condenser-Water Piping: 100 psig (690 kPa) OR 150 psig (1035 kPa), as directed.

#### D. Submittals

1. Product Data
2. Shop Drawings
3. Welding certificates.
4. Source quality-control test reports.
5. Field quality-control test reports.

#### E. Quality Assurance

1. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX.
2. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.

#### F. Project Conditions

1. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed utility interruptions.
  - b. Do not proceed with utility interruptions without the Owner's written permission.

### 1.2 PRODUCTS

#### A. Piping Materials

1. Refer to Part 1.3 "Piping Application" Article for applications of pipes, tubes, fittings, and joining methods.
2. Refer to Division 33 Section "Common Work Results For Utilities" for commonly used joining materials.

#### B. Steel Pipes And Fittings

1. Steel Pipe: ASTM A 53/A 53M, Type E, Grade B, Standard Weight; with plain ends.
2. Nipples: ASTM A 733, Standard Weight, seamless, carbon-steel pipe complying with ASTM A 53/A 53M.

3. Malleable-Iron, Threaded Fittings: ASME B16.3, Classes 150 **OR** 300, **as directed**, with threads according to ASME B1.20.1.
4. Cast-Iron, Threaded Fittings: ASME B16.4, Classes 125 **OR** 250, **as directed**, standard pattern, with threads according to ASME B1.20.1.
5. Steel Welding Fittings: ASME B16.9 **OR** ASTM A 234/A 234M, **as directed**, seamless or welded.
6. Ductile-Iron, Grooved-End Fittings: ASTM A 536, ductile-iron casting with dimensions matching piping.
7. Steel-Pipe, Keyed Couplings: AWWA C606 for steel-pipe dimensions. Include ferrous housing sections, gasket suitable for hot water, and bolts and nuts.

C. Conduit Piping

1. Description: Factory-fabricated and -assembled, airtight and watertight, drainable, pressure-tested piping with conduit, inner pipe supports, and insulated carrier piping. Fabricate so insulation can be dried in place by forcing dry air through conduit.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade B with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
  - a. Mineral-Wool Pipe Insulation: ASTM C 547, Type I, molded.
    - 1) Apparent Thermal Conductivity (k-Value): **0.31 at 200 deg F (0.044 at 93 deg C)** mean temperature.
    - 2) Density: Maximum **10 lb/cu. ft. (160 kg/cu. m)** average.
    - 3) Compressive Strength: **10 psig (69 kPa)** minimum at 5 percent deformation.
    - 4) Bands: ASTM A 666, Type 304, stainless steel, **3/4 inch (19 mm)** wide, **0.020 inch (0.5 mm)** thick.
  - b. Calcium Silicate Pipe Insulation: ASTM C 533, Type I; preformed, incombustible, inorganic, with non-asbestos fibrous reinforcement.
    - 1) Thermal Conductivity (k-Value): **0.60 at 500 deg F (0.087 at 260 deg C)**.
    - 2) Dry Density: **15 lb/cu. ft. (240 kg/cu. m)** maximum.
    - 3) Compressive Strength: **60 psig (414 kPa)** minimum at 5 percent deformation.
    - 4) Bands: ASTM A 666, Type 304, stainless steel, **3/4 inch (19 mm)** wide, **0.020 inch (0.5 mm)** thick.
  - c. Polyisocyanurate Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
    - 1) Thermal Conductivity (k-Value): **0.14 at 75 deg F (0.020 at 24 deg C)**.
    - 2) Service Temperature: **Minus 250 to plus 400 deg F (Minus 156 to plus 204 deg C)**.
    - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
    - 4) Minimum 90 percent closed cell.
    - 5) Dry Density: **2 lb/cu. ft. (32 kg/cu. m)** maximum.
    - 6) Compressive Strength: **35 psig (242 kPa)** minimum at 5 percent deformation.
    - 7) Water-Vapor Transmission: **1.26 perm inches (1.83 ng/Pa x s x m)** according to ASTM E 96.
  - d. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
    - 1) Thermal Conductivity (k-Value): **0.13 at 75 deg F (0.019 at 24 deg C)**.
    - 2) Service Temperature: **Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C)**.
    - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
    - 4) Minimum 90 percent closed cell.
    - 5) Dry Density: **2 lb/cu. ft. (32 kg/cu. m)** maximum.
    - 6) Compressive Strength: **35 psig (242 kPa)** minimum at 5 percent deformation.
    - 7) Water-Vapor Transmission: **1.26 perm inches (1.83 ng/Pa x s x m)** according to ASTM E 96.
4. Minimum Clearance:
  - a. Between Carrier Pipe Insulation and Conduit: **1 inch (25 mm)**.
  - b. Between Insulation of Multiple Carrier Pipes: **3/16 inch (4.75 mm)**.
  - c. Between Bottom of Carrier Pipe Insulation and Conduit: **1 inch (25 mm)**.
  - d. Between Bottom of Bare, Carrier Pipe and Casing: **1-3/8 inches (35 mm)**.

5. Conduit: Spiral wound, steel. Finish conduit with 2 coats of fusion-bonded epoxy, minimum **20 mils (0.50 mm)** thick. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article, **as directed**.  
**OR**  
Conduit: Spiral wound, bare steel. Cover with polyurethane foam insulation with a high-density polyethylene jacket; thickness indicated in Part 1.3 "Piping Application" Article.
6. Carrier Piping Supports within Conduit: Corrugated galvanized steel with a maximum spacing of **10 feet (3 m)**.
7. Fittings: Factory-fabricated and -insulated elbows and tees. Elbows may be bent pipe equal to carrier pipe. Tees shall be factory fabricated and insulated, and shall be compatible with the carrier pipe.
8. Expansion Offsets and Loops: Size casing to contain piping expansion.
9. Conduit accessories include the following:
  - a. Water Shed: Terminal end protector for carrier pipes entering building through floor, **3 inches (75 mm)** deep and **2 inches (50 mm)** larger than casing; terminate casing **20 inches (500 mm)** above the floor level.
  - b. Guides and Anchors: Steel plate welded to carrier pipes and to casing, complete with vent and drainage openings inside casing.
  - c. End Seals: Steel plate welded to carrier pipes and to casing, complete with drain and vent openings on vertical centerline.
  - d. Gland Seals: Packed stuffing box and gland follower mounted on steel plate, welded to end of casing, permitting axial movement of carrier piping, with drain and vent connections on vertical centerline.
  - e. Joint Kit: Half-shell, pourable or split insulation and shrink-wrap sleeve.
10. Source Quality Control: Factory test the conduit to **15 psig (105 kPa)** for a minimum of 2 minutes with no change in pressure. Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

**D. Cased Piping**

1. Description: Factory-fabricated piping with carrier pipe, insulation, and casing.
2. Carrier Pipe: Steel pipe complying with ASTM A 53/A 53M, Type E, Grade B with beveled **OR** socket, **as directed**, ends for welded joints.
3. Carrier Pipe Insulation:
  - a. Polyurethane Foam Pipe Insulation: ASTM C 591, preformed, rigid, cellular.
    - 1) Thermal Conductivity (k-Value): **0.13 at 75 deg F (0.019 at 24 deg C)**.
    - 2) Service Temperature: **Minus 250 to plus 200 deg F (Minus 156 to plus 93 deg C)**.
    - 3) Moisture Absorption: ASTM D 2842, maximum 0.054 percent by volume.
    - 4) Minimum 90 percent closed cell.
    - 5) Dry Density: **2 lb/cu. ft. (32 kg/cu. m)** maximum.
    - 6) Compressive Strength: **35 psig (242 kPa)** minimum at 5 percent deformation.
    - 7) Water-Vapor Transmission: **1.26 perm inches (1.83 ng/Pa x s x m)** according to ASTM E 96.
4. Casing: High-density polyethylene **OR** Filament-wound, fiberglass-reinforced polyester resin **OR** PVC, **as directed**.
5. Casing accessories include the following:
  - a. Joint Kit: Half-shell, pourable or split insulation, casing sleeve, and shrink-wrap sleeve.
  - b. Expansion Blanket: Elastomeric foam, formed to fit over piping.
  - c. End Seals: Shrink wrap the casing material to seal watertight around casing and carrier pipe.
6. Source Quality Control: Factory test the carrier pipe to 150 percent of the operating pressure of system. Furnish test certificates.

**E. Loose-Fill Insulation**

1. Granular, Loose-Fill Insulation: Inorganic, nontoxic, nonflammable, sodium potassium aluminum silicate with calcium carbonate filler. Include chemical treatment that renders insulation hydrophobic.



- a. Thermal Conductivity (k-Value): 0.60 at 175 deg F (0.087 at 79 deg C) and 0.65 at 300 deg F (0.094 at 149 deg C).
  - b. Application Temperature Range: 35 to 800 deg F (2 to 426 deg C).
  - c. Dry Density: 40 to 42 lb/cu. ft. (640 to 672 kg/cu. m).
  - d. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).
2. Powder, Loose-Fill Insulation: Inert, nontoxic, nonflammable, calcium carbonate particles. Include chemical treatment that renders insulation hydrophobic.
- a. Thermal Conductivity (k-Value): ASTM C 177, 0.58 at 100 deg F (0.084 at 37 deg C) and 0.68 at 300 deg F (0.098 at 149 deg C).
  - b. Application Temperature Range: Minus 273 to plus 480 deg F (Minus 169 to plus 250 deg C).
  - c. Dry Density: Approximately 60 lb/cu. ft. (960 kg/cu. m).
  - d. Strength: 12,000 lb/sq. ft. (58 600 kg/sq. m).

### 1.3 EXECUTION

- A. Earthwork: Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
- B. Piping Application
  1. Hot-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, loose-fill insulation.  
**OR**  
 Hot-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
    - a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.**OR**  
 Hot-Water Piping: Cased piping with polyurethane carrier-pipe insulation.
  2. Chilled-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel welding fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.  
**OR**  
 Chilled-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
    - a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.**OR**  
 Chilled-Water Piping: Cased piping with polyurethane carrier-pipe insulation.
  3. Condenser-Water Piping: Schedule 40 **OR** Schedule 80, **as directed**, steel pipe with cast-iron, threaded fittings and threaded **OR** steel welding fittings and welded **OR** ductile-iron, grooved-end fittings and mechanical, **as directed**, joints; granular **OR** powder, **as directed**, loose-fill insulation.  
**OR**  
 Condenser-Water Piping: Conduit piping with mineral-wool **OR** calcium silicate **OR** polyisocyanurate **OR** polyurethane, **as directed**, carrier-pipe insulation and with coated **OR** coated and insulated, **as directed**, conduit.
    - a. Insulation Thickness: 1 inch (25 mm) **OR** 2 inches (50 mm), **as directed**.**OR**  
 Condenser-Water Piping: Cased piping with polyurethane carrier-pipe insulation.
- C. Piping Installation

1. General Locations and Arrangements: Drawings indicate general location and arrangement of piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated, unless deviations to layout are approved.
  2. Remove any standing water in the bottom of trench.
  3. Bed the pipe on a minimum **6-inch (150-mm)** layer of granular fill material with a minimum **6-inch (150-mm)** clearance between the pipes.
  4. Do not insulate piping or backfill piping trench until field quality-control testing has been completed and results approved.
  5. Install piping at uniform grade of 0.2 percent upward in direction of flow or as indicated.
  6. Install components with pressure rating equal to or greater than system operating pressure.
  7. Install piping free of sags and bends.
  8. Install fittings for changes in direction and branch connections.
  9. Refer to Division 23 Section "Common Work Results For Hvac" for sleeves and mechanical sleeve seals through exterior building walls.
  10. Secure anchors with concrete thrust blocks. Concrete is specified in Division 03 Section "Cast-in-place Concrete".
  11. Connect to hydronic piping where it passes through the building wall. Hydronic piping inside the building is specified in Division 23 Section "Hydronic Piping".
- D. Loose-Fill Insulation Installation
1. Do not disturb the bottom of trench, or compact and stabilize it to ensure proper support.
  2. Remove any standing water in the bottom of trench.
  3. Form insulation trench by excavation or by installing drywall side forms to establish required height and width of the insulation.
  4. Support piping with proper pitch, separation, and clearance to backfill or side forms using temporary supporting devices that can be removed after back filling with insulation.
  5. Place insulation and backfill after field quality-control testing has been completed and results approved.
  6. Apply bitumastic coating to carbon-steel anchors and guides. Pour concrete thrust blocks and anchors. Refer to Division 03 Section "Cast-in-place Concrete" for concrete and reinforcement.
  7. Wrap piping at expansion loops and offsets with mineral-wool insulation of thickness appropriate for calculated expansion amount.
  8. Pour loose-fill insulation to required dimension agitating insulation to eliminate voids around piping.
  9. Remove temporary hangers and supports.
  10. Cover loose-fill insulation with polyethylene sheet a minimum of **4 mils (0.10 mm)** thick, and empty loose-fill insulation bags on top.
  11. Manually backfill **6 inches (150 mm)** of clean backfill. If mechanical compaction is required, manually backfill to **12 inches (300 mm)** before using mechanical-compaction equipment.
- E. Joint Construction
1. Refer to Division 33 Section "Common Work Results For Utilities" for basic piping joint construction.
  2. Keyed-Coupling Joints: Cut- or roll-groove pipes. Assemble joints with keyed couplings, gaskets, lubricant, and bolts.
  3. Conduit and Cased Piping Joints: Assemble sections and finish joints with pourable or split insulation, exterior jacket sleeve, and apply shrink-wrap seals as required by manufacturer's written installation instructions.
- F. Identification: Install continuous plastic underground warning tapes during back filling of trenches for underground hydronic distribution piping. Locate **6 to 8 inches (150 to 200 mm)** below finished grade, directly over piping. Refer to Division 31 Section "Earth Moving" for warning-tape materials and devices and their installation.
- G. Field Quality Control

1. Prepare hydronic piping for testing according to ASME B31.9 and as follows:
  - a. Leave joints, including welds, uninsulated and exposed for examination during test.
  - b. Isolate equipment. Do not subject equipment to test pressure.
  - c. Install relief valve set at pressure no more than one-third higher than test pressure.
  - d. Fill system with water. Where there is risk of freezing, air or a safe, compatible liquid may be used.
  - e. Use vents installed at high points to release trapped air while filling system.
2. Test hydronic piping as follows:
  - a. Subject hydronic piping to hydrostatic test pressure that is not less than 1.5 times the design pressure.
  - b. After hydrostatic test pressure has been applied for 10 minutes, examine joints for leakage. Remake leaking joints using new materials and repeat hydrostatic test until no leaks exist.
3. Test conduit as follows:
  - a. Seal vents and drains and subject conduit to 15 psig (105 kPa) for 4 hours with no loss of pressure. Repair leaks and retest as required.
4. Prepare a written report of testing.

END OF SECTION 33 14 13 23a

## SECTION 33 14 13 23b - GROUND-LOOP HEAT-PUMP PIPING

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for ground-loop, heat-pump piping. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. This Section includes piping for horizontal or vertical, direct-buried, ground-loop, heat-pump systems that operate between **23 and 104 deg F** (minus 5 and plus 40 deg C).

#### C. Performance Requirements

1. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
  - a. Ground-Loop, Heat-Pump Piping: **160 psig (1100 kPa) OR 200 psig (1380 kPa), as directed**

#### D. Submittals

1. Product Data: For the following:
  - a. Pipe and fittings.
  - b. Joining method and equipment.
  - c. Propylene glycol solution.
2. Field quality-control test reports.

### 1.2 PRODUCTS

#### A. Pipes And Fittings

1. PE Pipe: ASTM D 2239, SDR Numbers 5.3, 7, 9, or 11.5; with PE compound number required to achieve required system working pressure.
  - a. Molded PE Fittings: ASTM D 2683 or ASTM D 3261, PE resin, socket- or butt-fusion type, made to match PE pipe dimensions and class.
2. U-Bend Assembly: Factory fabricated with embossed depth stamp every **24 inches (600 mm) OR 36 inches (900 mm), as directed** from U-bend.

#### B. Borehole Backfill

1. Surface Seal: Bentonite **OR** Cement, **as directed**, with thermal conductivity greater than **1.2 Btu/h x sq. ft. x deg F (0.7 W/sq. m x K)**.
2. Backfill below Surface Seal: Natural or manufactured sand specified in Division 31 Section "Earth Moving".

#### C. Antifreeze Solution

1. Propylene Glycol: Minimum 99 percent propylene glycol with corrosion inhibitors and environmental stabilizer additives to be mixed with water to protect the piping circuit and connected equipment from physical damage from freezing or corrosion.
2. Quantity: Sufficient solution for initial system startup and for preventive maintenance for one year from date of Final Completion.
3. Dilution Water: Chloride content shall be less than 25 ppm, sulfate less than 25 ppm, and hardness less than 100 ppm.

### 1.3 EXECUTION

#### A. Earthwork

1. Excavating, trenching, warning tape, and backfilling are specified in Division 31 Section "Earth Moving".

#### B. Horizontal Piping Installation

1. Separate trenches by **10 feet (3 m)** minimum, unless otherwise indicated. Remove rocks in trenches that could contact pipe.
2. Backfill to **24 inches (600 mm)** above pipe with mud developed from excavated rock-free soil or with sand, pea gravel, or fly ash. Backfill from slurry level to grade with excavated soil, compacting as specified for pipe burial in Division 31 Section "Earth Moving".
3. Extend pipe from trench onto the bottom of the body of water at an elevation that is at least **12 inches (300 mm)** below frost line. Seal membrane or impervious liner under the body of water after installing piping.
4. Install PE piping in trenches according to ASTM D 2774 or ASTM F 645.
  - a. Clean PE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
5. Purge, flush, and pressure test piping before backfilling trenches.
6. Install continuous detectable warning tape for underground piping. Locate tape a minimum of **24 inches (600 mm)** below finished grade, directly over piping. Underground warning tapes are specified in Division 31 Section "Earth Moving".
7. Common piping installation requirements are specified in Division 23 Section "Common Work Results For Hvac".

#### C. Vertical Piping Installation

1. Install PE piping in boreholes according to ASTM D 2774 or ASTM F 645.
  - a. Clean PE pipe and fittings and make heat-fusion joints according to ASTM D 2657. Minimize number of joints.
2. Purge, flush, and pressure test piping before backfilling boreholes.
3. After installation of loop pipe in borehole, fill piping loop with water or antifreeze solution, and pump backfill into borehole to discharge at base of borehole.
4. Fill borehole with backfill to a point at least **60 inches (1524 mm)** below grade and backfill remainder with surface seal material.
5. Extend piping and connect to water-source, ground-loop, heat-pump piping systems at outside face of building wall in locations and pipe sizes indicated.
  - a. Terminate water-service piping at building wall until building water-source, ground-loop, heat-pump piping systems are installed. Terminate piping with caps. Make connections to building water-source, ground-loop, heat-pump piping systems when those systems are installed.
6. Wall sleeves are specified in Division 23 Section "Common Work Results For Hvac".
7. Mechanical sleeve seals are specified in Division 22 Section "Common Work Results For Plumbing".

#### D. Antifreeze Solution Fill

1. Fill system with required quantity of propylene glycol and water to provide **minus 10 deg F (minus 23 deg C)** freezing temperature.
2. Test the dilute solution using gas chromatography to verify concentration of propylene glycol, and forward report to the Owner.

#### E. Connections

1. Drawings indicate general arrangement of piping, fittings, and specialties.

#### F. Field Quality Control

1. Piping Tests: Fill piping 24 hours before testing and apply test pressure to stabilize piping. Use potable water only.
2. Hydrostatic Tests: Test at not less than 1-1/2 times the pipe working-pressure rating allowing for static pressure of borehole depth.
  - a. Increase pressure in 50-psig (345-kPa) increments and inspect each joint between increments. Hold at test pressure for 30 minutes. Slowly increase to next test pressure increment and hold for 30 minutes. After testing at maximum test pressure, reduce pressure to 30 psig (207 kPa). Hold for 90 minutes, and measure pressure at 30-minute intervals. Repair leaks and retest until no leaks exist.
3. Prepare reports of testing activity.

END OF SECTION 33 14 13 23b

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Task	Specification	Specification Description
33 14 13 23	01 22 16 00	No Specification Required
33 14 13 23	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 23	13 12 13 00	Water Distribution
33 14 13 23	23 11 23 00a	Monitoring Wells
33 14 13 23	22 11 23 23	Water Supply Wells
33 14 13 23	22 05 76 00	Sanitary Sewerage
33 14 13 23	32 91 19 13a	Septic Tank Systems
33 14 13 23	31 05 13 00	Subdrainage
33 14 13 23	33 42 11 00	Storm Drainage
33 14 13 36	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 36	22 11 23 23	Water Supply Wells
33 14 13 36	33 14 13 23a	Hydronic Distribution
33 14 13 36	23 05 29 00	Steam Distribution
33 14 13 39	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 39	13 12 13 00	Water Distribution
33 14 13 43	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 13 43	13 12 13 00	Water Distribution
33 14 13 43	22 11 23 23	Water Supply Wells
33 14 13 43	22 05 76 00	Sanitary Sewerage
33 14 13 43	33 14 13 23a	Hydronic Distribution
33 14 13 43	23 05 29 00	Steam Distribution
33 14 13 53	01 22 16 00	No Specification Required
33 14 13 53	07 63 00 00	Common Work Results for Fire Suppression
33 14 13 53	07 63 00 00a	Common Work Results for Plumbing
33 14 13 53	07 63 00 00b	Common Work Results for HVAC
33 14 13 53	22 11 16 00	Domestic Water Piping
33 14 13 53	22 11 16 00a	Sanitary Waste And Vent Piping
33 14 13 53	22 11 16 00b	Storm Drainage Piping
33 14 13 53	22 11 16 00c	Hydronic Piping
33 14 13 53	22 11 16 00d	Steam And Condensate Piping
33 14 13 53	22 11 16 00e	Refrigerant Piping
33 14 13 53	22 11 16 00f	General-Service Compressed-Air Piping
33 14 19 00	01 22 16 00	No Specification Required
33 14 19 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 14 19 00	13 12 13 00	Water Distribution
33 19 13 23	13 12 13 00	Water Distribution
33 19 13 23	21 05 19 00	Meters and Gages for Plumbing Piping
33 19 13 23	21 05 19 00a	Meters and Gages for HVAC Piping
33 19 16 23	01 22 16 00	No Specification Required
33 19 16 23	13 12 13 00	Water Distribution
33 19 16 23	21 05 19 00	Meters and Gages for Plumbing Piping
33 19 16 23	21 05 19 00a	Meters and Gages for HVAC Piping
33 19 19 00	01 22 16 00	No Specification Required
33 19 19 00	13 12 13 00	Water Distribution
33 19 19 00	21 05 19 00	Meters and Gages for Plumbing Piping
33 19 19 00	21 05 19 00a	Meters and Gages for HVAC Piping
33 31 11 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 31 11 00	33 14 13 23	Sand Drains
33 31 11 00	13 12 13 00	Water Distribution
33 31 11 00	23 11 23 00a	Monitoring Wells
33 31 11 00	22 11 23 23	Water Supply Wells
33 31 11 00	22 05 76 00	Sanitary Sewerage
33 31 11 00	32 91 19 13a	Septic Tank Systems
33 31 11 00	33 14 13 23a	Hydronic Distribution
33 31 11 00	31 05 13 00	Subdrainage





33 31 11 00	33 42 11 00	Storm Drainage
33 32 16 00	01 22 16 00	No Specification Required
33 32 16 00	22 13 29 13b	Sewage Pumps
33 34 13 13	32 91 19 13a	Septic Tank Systems
33 34 13 23	32 91 19 13a	Septic Tank Systems
33 34 13 33	32 91 19 13a	Septic Tank Systems
33 34 51 00	32 91 19 13a	Septic Tank Systems
33 34 53 13	32 91 19 13a	Septic Tank Systems
33 34 56 00	32 91 19 13a	Septic Tank Systems
33 41 16 13	01 22 16 00	No Specification Required
33 41 16 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 41 16 13	22 05 76 00	Sanitary Sewerage
33 41 16 13	32 91 19 13a	Septic Tank Systems
33 41 16 13	31 05 13 00	Subdrainage
33 41 16 13	33 42 11 00	Storm Drainage
33 41 16 13	22 11 16 00b	Storm Drainage Piping
33 41 16 13	22 05 76 00a	Storm Drainage Piping Specialties
33 41 19 13	21 05 23 00	Piped Utilities Basic Materials And Methods
33 41 19 13	31 05 13 00	Subdrainage

NOT FOR BID

## SECTION 33 42 11 00 - STORM DRAINAGE

### 1.1 GENERAL

#### A. Description Of Work

1. This specification covers the furnishing and installation of materials for storm drainage. Products shall be as follows or as directed by the Owner. Installation procedures shall be in accordance with the product manufacturer's recommendations. Demolition and removal of materials shall be as required to support the work.

#### B. Summary

1. Section Includes:
  - a. Pipe and fittings.
  - b. Nonpressure transition couplings.
  - c. Pressure pipe couplings.
  - d. Expansion joints and deflection fittings.
  - e. Backwater valves.
  - f. Cleanouts.
  - g. Drains.
  - h. Encasement for piping.
  - i. Manholes.
  - j. Channel drainage systems.
  - k. Catch basins.
  - l. Stormwater inlets.
  - m. Stormwater detention structures.
  - n. Pipe outlets.
  - o. Dry wells.
  - p. Stormwater disposal systems.

#### C. Definitions

1. FRP: Fiberglass-reinforced plastic.

#### D. Submittals

1. Product Data: For each type of product indicated.
2. Shop Drawings:
  - a. Manholes: Include plans, elevations, sections, details, frames, and covers.
  - b. Catch basins, stormwater inlets, and dry wells. Include plans, elevations, sections, details, frames, covers, and grates.
  - c. Stormwater Detention Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.
3. Coordination Drawings: Show pipe sizes, locations, and elevations. Show other piping in same trench and clearances from storm drainage system piping. Indicate interface and spatial relationship between manholes, piping, and proximate structures.
4. Profile Drawings: Show system piping in elevation. Draw profiles at horizontal scale of not less than **1 inch equals 50 feet (1:500)** and vertical scale of not less than **1 inch equals 5 feet (1:50)**. Indicate manholes and piping. Show types, sizes, materials, and elevations of other utilities crossing system piping.
5. Product Certificates: For each type of cast-iron soil pipe and fitting, from manufacturer.
6. Field quality-control reports.

#### E. Delivery, Storage, And Handling

1. Do not store plastic manholes, pipe, and fittings in direct sunlight.
2. Protect pipe, pipe fittings, and seals from dirt and damage.
3. Handle manholes according to manufacturer's written rigging instructions.



4. Handle catch basins and stormwater inlets according to manufacturer's written rigging instructions.

F. Project Conditions

1. Interruption of Existing Storm Drainage Service: Do not interrupt service to facilities occupied by the Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
  - a. Notify the Owner no fewer than two days in advance of proposed interruption of service.
  - b. Do not proceed with interruption of service without the Owner written permission.

## 1.2 PRODUCTS

A. Hub-And-Spigot, Cast-Iron Soil Pipe And Fittings

1. Pipe and Fittings: ASTM A 74, Service class **OR** Extra-Heavy class, **as directed**.
2. Gaskets: ASTM C 564, rubber.
3. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

B. Hubless Cast-Iron Soil Pipe And Fittings

1. Pipe and Fittings: ASTM A 888 or CISPI 301.
2. CISPI-Trademarked, Shielded Couplings:
  - a. Description: ASTM C 1277 and CISPI 310, with stainless-steel corrugated shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
3. Heavy-Duty, Shielded Couplings:
  - a. Description: ASTM C 1277 and ASTM C 1540, with stainless-steel shield; stainless-steel bands and tightening devices; and ASTM C 564, rubber sleeve with integral, center pipe stop.
4. Cast-Iron, Shielded Couplings:
  - a. Description: ASTM C 1277 and ASTM A 48/A 48M, two-piece, cast-iron housing; stainless-steel bolts and nuts; and ASTM C 564, rubber sleeve with integral, center pipe stop.

C. Ductile-Iron, Culvert Pipe And Fittings

1. Pipe: ASTM A 716, for push-on joints.
2. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
3. Compact Fittings: AWWA C153, for push-on joints.
4. Gaskets: AWWA C111, rubber.

D. Ductile-Iron, Pressure Pipe And Fittings

1. Push-on-Joint Piping:
  - a. Pipe: AWWA C151, for push-on joints.
  - b. Standard Fittings: AWWA C110, ductile or gray iron, for push-on joints.
  - c. Compact Fittings: AWWA C153, for push-on joints.
  - d. Gaskets: AWWA C111, rubber, of shape matching pipe and fittings.
2. Mechanical-Joint Piping:
  - a. Pipe: AWWA C151, with bolt holes in bell.
  - b. Standard Fittings: AWWA C110, ductile or gray iron, with bolt holes in bell.
  - c. Compact Fittings: AWWA C153, with bolt holes in bells.
  - d. Glands: Cast or ductile iron, with bolt holes and high-strength, cast-iron or high-strength, low-alloy steel bolts and nuts.
  - e. Gaskets: AWWA C111, rubber, of shape matching pipe, fittings, and glands.

E. Steel Pipe And Fittings

1. Corrugated-Steel Pipe and Fittings: ASTM A 760/A 760M, Type I with fittings of similar form and construction as pipe.
  - a. Special-Joint Bands: Corrugated steel with O-ring seals.
  - b. Standard-Joint Bands: Corrugated steel.
  - c. Coating: Aluminum **OR** Zinc, **as directed**.
- F. Aluminum Pipe And Fittings
  1. Corrugated Aluminum Pipe and Fittings: ASTM B 745/B 745M, Type I with fittings of similar form and construction as pipe.
    - a. Special-Joint Bands: Corrugated steel with O-ring seals.
    - b. Standard-Joint Bands: Corrugated steel.
- G. ABS Pipe And Fittings
  1. ABS Sewer Pipe and Fittings: ASTM D 2751, with bell-and-spigot ends for gasketed joints.
    - a. **NPS 3 to NPS 6 (DN 80 to DN 150)**: SDR 35.
    - b. **NPS 8 to NPS 12 (DN 200 to DN 300)**: SDR 42.
  2. Gaskets: ASTM F 477, elastomeric seals.
- H. PE Pipe And Fittings
  1. Corrugated PE Drainage Pipe and Fittings **NPS 3 to NPS 10 (DN 80 to DN 250)**: AASHTO M 252M, Type S, with smooth waterway for coupling joints.
    - a. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with tube and fittings.
    - b. Soiltight Couplings: AASHTO M 252M, corrugated, matching tube and fittings.
  2. Corrugated PE Pipe and Fittings **NPS 12 to NPS 60 (DN 300 to DN 1500)**: AASHTO M 294M, Type S, with smooth waterway for coupling joints.
    - a. Silttight Couplings: PE sleeve with ASTM D 1056, Type 2, Class A, Grade 2 gasket material that mates with pipe and fittings.
    - b. Soiltight Couplings: AASHTO M 294M, corrugated, matching pipe and fittings.
- I. PVC Pipe And Fittings
  1. PVC Cellular-Core Piping:
    - a. PVC Cellular-Core Pipe and Fittings: ASTM F 891, Sewer and Drain Series, PS 50 minimum stiffness, PVC cellular-core pipe with plain ends for solvent-cemented joints.
    - b. Fittings: ASTM D 3034, SDR 35, PVC socket-type fittings.
  2. PVC Corrugated Sewer Piping:
    - a. Pipe: ASTM F 949, PVC, corrugated pipe with bell-and-spigot ends for gasketed joints.
    - b. Fittings: ASTM F 949, PVC molded or fabricated, socket type.
    - c. Gaskets: ASTM F 477, elastomeric seals.
  3. PVC Profile Sewer Piping:
    - a. Pipe: ASTM F 794, PVC profile, gravity sewer pipe with bell-and-spigot ends for gasketed joints.
    - b. Fittings: ASTM D 3034, PVC with bell ends.
    - c. Gaskets: ASTM F 477, elastomeric seals.
  4. PVC Type PSM Sewer Piping:
    - a. Pipe: ASTM D 3034, SDR 35, PVC Type PSM sewer pipe with bell-and-spigot ends for gasketed joints.
    - b. Fittings: ASTM D 3034, PVC with bell ends.
    - c. Gaskets: ASTM F 477, elastomeric seals.
  5. PVC Gravity Sewer Piping:
    - a. Pipe and Fittings: ASTM F 679, T-1 **OR** T-2, **as directed**, wall thickness, PVC gravity sewer pipe with bell-and-spigot ends and with integral ASTM F 477, elastomeric seals for gasketed joints.
  6. PVC Pressure Piping:
    - a. Pipe: AWWA C900, Class 100 **OR** Class 150 **OR** Class 200, **as directed**, PVC pipe with bell-and-spigot ends for gasketed joints.

- b. Fittings: AWWA C900, Class 100 **OR** Class 150 **OR** Class 200, **as directed**, PVC pipe with bell ends
    - c. Gaskets: ASTM F 477, elastomeric seals.
  - 7. PVC Water-Service Piping:
    - a. Pipe: ASTM D 1785, Schedule 40 **OR** Schedule 80, **as directed**, PVC, with plain ends for solvent-cemented joints.
    - b. Fittings: ASTM D 2466, Schedule 40 **OR** ASTM D 2467, Schedule 80, **as directed**, PVC, socket type.
- J. Fiberglass Pipe And Fittings
  - 1. Fiberglass Sewer Pipe: ASTM D 3262, RTRP for gasketed joints fabricated with Type 2, polyester **OR** Type 4, epoxy, **as directed**, resin.
    - a. Liner: Reinforced thermoset **OR** Nonreinforced thermoset **OR** Thermoplastic **OR** No liner, **as directed**.
    - b. Grade: Reinforced, surface layer matching pipe resin **OR** Nonreinforced, surface layer matching pipe resin **OR** No surface layer, **as directed**.
    - c. Stiffness: 9 psig (62 kPa) **OR** 18 psig (124 kPa) **OR** 36 psig (248 kPa) **OR** 72 psig (496 kPa), **as directed**.
  - 2. Fiberglass Nonpressure Fittings: ASTM D 3840, RTRF for gasketed joints.
    - a. Laminating Resin: Type 1, polyester **OR** Type 2, epoxy, **as directed**, resin.
    - b. Reinforcement: Grade with finish compatible with resin.
  - 3. Gaskets: ASTM F 477, elastomeric seals.
- K. Concrete Pipe And Fittings
  - 1. Nonreinforced-Concrete Sewer Pipe and Fittings: ASTM C 14 (ASTM C 14M), Class 1 **OR** Class 2 **OR** Class 3, **as directed**, with bell-and-spigot **OR** tongue-and-groove, **as directed** ends and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets **OR** sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant, **as directed**.
  - 2. Reinforced-Concrete Sewer Pipe and Fittings: ASTM C 76 (ASTM C 76M).
    - a. Bell-and-spigot **OR** Tongue-and-groove, **as directed**, ends and gasketed joints with ASTM C 443 (ASTM C 443M), rubber gaskets **OR** sealant joints with ASTM C 990 (ASTM C 990M), bitumen or butyl-rubber sealant, **as directed**.
    - b. Class I, Wall A **OR** Wall B, **as directed**.
    - c. Class II, Wall A **OR** Wall B **OR** Wall C, **as directed**.
    - d. Class III, Wall A **OR** Wall B **OR** Wall C, **as directed**.
    - e. Class IV, Wall A **OR** Wall B **OR** Wall C, **as directed**.
    - f. Class V, Wall B **OR** Wall C, **as directed**.
- L. Nonpressure Transition Couplings
  - 1. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground nonpressure piping. Include ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
  - 2. Sleeve Materials:
    - a. For Concrete Pipes: ASTM C 443 (ASTM C 443M), rubber.
    - b. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
    - c. For Fiberglass Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
    - d. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
    - e. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
  - 3. Unshielded, Flexible Couplings:
    - a. Description: Elastomeric sleeve, with stainless-steel shear ring, **as directed**, and corrosion-resistant-metal tension band and tightening mechanism on each end.
  - 4. Shielded, Flexible Couplings:

- a. Description: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
  5. Ring-Type, Flexible Couplings:
    - a. Description: Elastomeric compression seal with dimensions to fit inside bell of larger pipe and for spigot of smaller pipe to fit inside ring.
- M. Pressure Pipe Couplings
  1. Description: AWWA C219, tubular-sleeve coupling, with center sleeve, gaskets, end rings, and bolt fasteners.
  2. Metal, bolted, sleeve-type, reducing or transition coupling, for joining underground pressure piping. Include **150-psig (1035-kPa) OR 200-psig (1380-kPa)**, **as directed**, minimum pressure rating and ends sized to fit adjoining pipes.
  3. Center-Sleeve Material: Manufacturer's standard **OR** Carbon steel **OR** Stainless steel **OR** Ductile iron **OR** Malleable iron, **as directed**.
  4. Gasket Material: Natural or synthetic rubber.
  5. Metal Component Finish: Corrosion-resistant coating or material.
- N. Expansion Joints And Deflection Fittings
  1. Ductile-Iron Flexible Expansion Joints:
    - a. Description: Compound fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include two gasketed ball-joint sections and one or more gasketed sleeve sections, rated for **250-psig (1725-kPa)** minimum working pressure and for offset and expansion indicated.
  2. Ductile-Iron Expansion Joints:
    - a. Description: Three-piece assembly of telescoping sleeve with gaskets and restrained-type, ductile-iron or steel with protective coating, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Include rating for **250-psig (1725-kPa)** minimum working pressure and for expansion indicated.
  3. Ductile-Iron Deflection Fittings:
    - a. Description: Compound-coupling fitting, with ball joint, flexing section, gaskets, and restrained-joint ends, complying with AWWA C110 or AWWA C153. Include rating for **250-psig (1725-kPa)** minimum working pressure and for up to 15 degrees of deflection.
- O. Backwater Valves
  1. Cast-Iron Backwater Valves:
    - a. Description: ASME A112.14.1, gray-iron body and bolted cover, with bronze seat.
    - b. Horizontal type; with swing check valve and hub-and-spigot ends.
    - c. Combination horizontal and manual gate-valve type; with swing check valve, integral gate valve, and hub-and-spigot ends.
    - d. Terminal type; with bronze seat, swing check valve, and hub inlet.
  2. Plastic Backwater Valves:
    - a. Description: Horizontal type; with PVC body, PVC removable cover, and PVC swing check valve.
- P. Cleanouts
  1. Cast-Iron Cleanouts:
    - a. Description: ASME A112.36.2M, round, gray-iron housing with clamping device and round, secured, scoriated, gray-iron cover. Include gray-iron ferrule with inside calk or spigot connection and countersunk, tapered-thread, brass closure plug.
    - b. Top-Loading Classification(s): Light Duty **OR** Medium Duty **OR** Heavy Duty **OR** Extra-Heavy Duty, **as directed**.
    - c. Sewer Pipe Fitting and Riser to Cleanout: ASTM A 74, Service class, cast-iron soil pipe and fittings.
  2. Plastic Cleanouts:



- a. Description: PVC body with PVC threaded plug. Include PVC sewer pipe fitting and riser to cleanout of same material as sewer piping.

#### Q. Drains

##### 1. Cast-Iron Area Drains:

- a. Description: ASME A112.6.3 gray-iron round body with anchor flange and round secured **OR** non-secured, **as directed**, grate. Include bottom outlet with inside calk or spigot connection, of sizes indicated.
- b. Top-Loading Classification(s): Medium Duty **OR** Heavy Duty, **as directed**.

##### 2. Cast-Iron Trench Drains:

- a. Description: ASME A112.6.3, **6-inch- (150-mm-)** wide top surface, rectangular body with anchor flange or other anchoring device, and rectangular secured **OR** non-secured, **as directed**, grate. Include units of total length indicated and quantity of bottom outlets with inside calk or spigot connections, of sizes indicated.
- b. Top-Loading Classification(s): Medium Duty **OR** Heavy Duty **OR** Extra-Heavy Duty **OR** Medium and Heavy Duty **OR** Medium and Extra-Heavy Duty **OR** Heavy and Extra-Heavy Duty **OR** Medium, Heavy, and Extra-Heavy Duty, **as directed**.

##### 3. Steel Trench Drains:

- a. Description: Factory fabricated from ASTM A 242/A 242M, welded steel plate, to form rectangular body with uniform bottom downward slope of 2 percent toward outlet, anchor flange, and grate. Include units of total length indicated, bottom outlet of size indicated, outlet strainer, acid-resistant enamel coating on inside and outside surfaces, and grate with openings of total free area at least two times cross-sectional area of outlet.
- b. Plate Thicknesses: **1/8 inch (3.2 mm) OR 1/4 inch (6.4 mm), as directed**.
- c. Overall Widths: **7-1/2 inches (190 mm) OR 12-1/3 inches (313 mm), as directed**.
  - 1) Grate Openings: **1/4 inch (6.4 mm) circular OR 3/8 inch (9.5 mm) circular OR 3/8-by-3-inch (9.5-by-76-mm) slots, as directed**.

#### R. Encasement For Piping

- 1. Standard: ASTM A 674 or AWWA C105.
- 2. Material: Linear low-density polyethylene film of **0.008-inch (0.20-mm) OR** high-density, cross-laminated polyethylene film of **0.004-inch (0.10-mm), as directed**, minimum thickness.
- 3. Form: Sheet **OR** Tube, **as directed**.
- 4. Color: Black **OR** Natural, **as directed**.

#### S. Manholes

##### 1. Standard Precast Concrete Manholes:

- a. Description: **ASTM C 478 (ASTM C 478M)**, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
- b. Diameter: **48 inches (1200 mm)** minimum unless otherwise indicated.
- c. Ballast: Increase thickness of precast concrete sections or add concrete to base section as required to prevent flotation.
- d. Base Section: **6-inch (150-mm)** minimum thickness for floor slab and **4-inch (102-mm)** minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
- e. Riser Sections: **4-inch (102-mm)** minimum thickness, and lengths to provide depth indicated.
- f. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated, and top of cone of size that matches grade rings.
- g. Joint Sealant: **ASTM C 990 (ASTM C 990M)**, bitumen or butyl rubber.
- h. Resilient Pipe Connectors: **ASTM C 923 (ASTM C 923M)**, cast or fitted into manhole walls, for each pipe connection.
- i. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, **1/2-inch (13-mm)** steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, **1/2-inch (13-mm)** steel reinforcing



rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at **12- to 16-inch (300- to 400-mm)** intervals. Omit steps if total depth from floor of manhole to finished grade is less than **60 inches (1500 mm)**.

- j. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

**OR**

Grade Rings: Reinforced-concrete rings, **6- to 9-inch (150- to 225-mm)** total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

2. Designed Precast Concrete Manholes:

- a. Description: ASTM C 913; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for sealant joints.
- b. Ballast: Increase thickness of one or more precast concrete sections or add concrete to manhole as required to prevent flotation.
- c. Joint Sealant: **ASTM C 990 (ASTM C 990M)**, bitumen or butyl rubber.
- d. Resilient Pipe Connectors: **ASTM C 923 (ASTM C 923M)**, cast or fitted into manhole walls, for each pipe connection.
- e. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, **1/2-inch (13-mm)** steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, **1/2-inch (13-mm)** steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at **12- to 16-inch (300- to 400-mm)** intervals. Omit steps if total depth from floor of manhole to finished grade is less than **60 inches (1500 mm)**.
- f. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

**OR**

Grade Rings: Reinforced-concrete rings, **6- to 9-inch (150- to 225-mm)** total thickness, to match diameter of manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope.

3. Fiberglass Manholes:

- a. Description: ASTM D 3753.
- b. Diameter: **48 inches (1200 mm)** minimum unless otherwise indicated.
- c. Ballast: Increase thickness of concrete base as required to prevent flotation.
- d. Base Section: Concrete, **6-inch (150-mm)** minimum thickness.
- e. Resilient Pipe Connectors (if required): **ASTM C 923 (ASTM C 923M)**, cast or fitted into manhole walls, for each pipe connection.
- f. Steps: Individual FRP steps or FRP ladder, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at **12- to 16-inch (300- to 400-mm)** intervals. Omit steps if total depth from floor of manhole to finished grade is less than **60 inches (1500 mm)**.
- g. Adjusting Rings: Interlocking HDPE rings with level or sloped edge in thickness and diameter matching manhole frame and cover, and of height required to adjust manhole frame and cover to indicated elevation and slope. Include sealant recommended by ring manufacturer.

**OR**

Grade Rings: Reinforced-concrete rings, **6- to 9-inch (150- to 225-mm)** total thickness, to match diameter of manhole frame and cover, and height as required to adjust manhole frame and cover to indicated elevation and slope.

4. Manhole Frames and Covers:



- a. Description: Ferrous; **24-inch (610-mm)** ID by **7- to 9-inch (175- to 225-mm)** riser with **4-inch- (102-mm-)** minimum width flange and **26-inch- (660-mm-)** diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."
- b. Material: ASTM A 536, Grade 60-40-18 ductile **OR** ASTM A 48/A 48M, Class 35 gray, **as directed**, iron unless otherwise indicated.

T. Concrete

1. General: Cast-in-place concrete according to ACI 318, **ACI 350/350R (ACI 350M/350RM)**, and the following:
  - a. Cement: ASTM C 150, Type II.
  - b. Fine Aggregate: ASTM C 33, sand.
  - c. Coarse Aggregate: ASTM C 33, crushed gravel.
  - d. Water: Potable.
2. Portland Cement Design Mix: **4000 psi (27.6 MPa)** minimum, with 0.45 maximum water/cementitious materials ratio.
  - a. Reinforcing Fabric: ASTM A 1064/A 1064M, steel, welded wire fabric, plain.
  - b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.
3. Manhole Channels and Benches: Factory or field formed from concrete. Portland cement design mix, **4000 psi (27.6 MPa)** minimum, with 0.45 maximum water/cementitious materials ratio. Include channels and benches in manholes.
  - a. Channels: Concrete invert, formed to same width as connected piping, with height of vertical sides to three-fourths of pipe diameter. Form curved channels with smooth, uniform radius and slope.
    - 1) Invert Slope: **1 OR 2, as directed**, percent through manhole.
  - b. Benches: Concrete, sloped to drain into channel.
    - 1) Slope: **4 OR 8, as directed**, percent.
4. Ballast and Pipe Supports: Portland cement design mix, **3000 psi (20.7 MPa)** minimum, with 0.58 maximum water/cementitious materials ratio.
  - a. Reinforcing Fabric: ASTM A 1064/A 1064M, steel, welded wire fabric, plain.
  - b. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (420 MPa) deformed steel.

U. Polymer-Concrete, Channel Drainage Systems

1. General Requirements for Polymer-Concrete, Channel Drainage Systems: Modular system of precast, polymer-concrete channel sections, grates, and appurtenances; designed so grates fit into channel recesses without rocking or rattling. Include quantity of units required to form total lengths indicated.
2. Sloped-Invert, Polymer-Concrete Systems:
  - a. Channel Sections:
    - 1) Interlocking-joint, precast, modular units with end caps.
    - 2) **4-inch (102-mm)** inside width and deep, rounded bottom, with built-in invert slope of 0.6 percent and with outlets in quantities, sizes, and locations indicated.
    - 3) Extension sections necessary for required depth.
    - 4) Frame: Include gray-iron or steel frame for grate.
  - b. Grates:
    - 1) Manufacturer's designation "Heavy **OR** "Medium, **as directed**, Duty," with slots or perforations that fit recesses in channels.
    - 2) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
  - c. Covers: Solid gray iron if indicated.
  - d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
3. Narrow-Width, Level-Invert, Polymer-Concrete Systems:
  - a. Channel Sections:
    - 1) Interlocking-joint, precast, modular units with end caps.

- 2) **5-inch (127-mm)** inside width and **9-3/4-inch- (248-mm-)** deep, rounded bottom, with level invert and with **NPS 4 (DN 100)** outlets in quantities, sizes, and locations indicated.
- b. Grates:
  - 1) Slots or perforations that fit recesses in channels.
  - 2) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed**.
- c. Covers: Solid gray iron if indicated.
- d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
4. Wide-Width, Level-Invert, Polymer-Concrete Systems:
  - a. Channel Sections:
    - 1) Interlocking-joint, precast, modular units with end caps.
    - 2) **8-inch (203-mm)** inside width and **13-3/4-inch- (350-mm-)** deep, rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.
  - b. Grates:
    - 1) Slots or other openings that fit recesses in channels.
    - 2) Material: Fiberglass **OR** Gray iron, **as directed**.
  - c. Covers: Solid gray iron if indicated.
  - d. Locking Mechanism: Manufacturer's standard device for securing grates to channel sections.
5. Drainage Specialties: Precast, polymer-concrete units.
  - a. Large Catch Basins:
    - 1) **24-by-12-inch (610-by-305-mm)** polymer-concrete body, with outlets in quantities and sizes indicated.
    - 2) Gray-iron slotted grate.
    - 3) Frame: Include gray-iron or steel frame for grate.
  - b. Small Catch Basins:
    - 1) **19- to 24-inch by approximately 6-inch (483- to 610-mm by approximately 150-mm)** polymer-concrete body, with outlets in quantities and sizes indicated.
    - 2) Gray-iron slotted grate.
    - 3) Frame: Include gray-iron or steel frame for grate.
  - c. Oil Interceptors:
    - 1) Polymer-concrete body with interior baffle and four steel support channels and two **1/4-inch- (6.4-mm-)** thick, steel-plate covers.
    - 2) Steel-plate covers.
    - 3) Capacity: **140 gal. (530 L) OR 200 gal. (757 L) OR 260 gal. (984 L), as directed**.
    - 4) Inlet and Outlet: **NPS 4 (DN 100) OR NPS 6 (DN 150), as directed**.
  - d. Sediment Interceptors:
    - 1) **27-inch- (686-mm-)** square, polymer-concrete body, with outlets in quantities and sizes indicated.
    - 2) **24-inch- (610-mm-)** square, gray-iron frame and slotted grate.
6. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
7. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.
- V. Plastic, Channel Drainage Systems
  1. General Requirements for Plastic, Channel Drainage Systems:
    - a. Modular system of plastic channel sections, grates, and appurtenances.
    - b. Designed so grates fit into frames without rocking or rattling.
    - c. Number of units required to form total lengths indicated.
  2. Fiberglass Systems:
    - a. Channel Sections:
      - 1) Interlocking-joint, fiberglass modular units, with built-in invert slope of approximately 1 percent and with end caps.
      - 2) Rounded or inclined inside bottom surface, with outlets in quantities, sizes, and locations indicated.

- 3) Width: **6 inches (150 mm) OR 6 or 8 inches (150 or 203 mm) OR 8 inches (203 mm), as directed.**
- b. Factory- or field-attached frames that fit channel sections and grates.
  - 1) Material: Galvanized steel **OR** Stainless steel **OR** Manufacturer's standard metal, **as directed.**
- c. Grates with slots or perforations that fit frames.
  - 1) Material: Fiberglass **OR** Galvanized steel **OR** Gray iron **OR** Stainless steel, **as directed.**
- d. Covers: Solid gray iron if indicated.
- e. Drainage Specialties:
  - 1) Large Catch Basins: **24-inch- (610-mm-)** square plastic body, with outlets in quantities and sizes indicated. Include gray-iron frame and slotted grate.
  - 2) Small Catch Basins: **12-by-24-inch (305-by-610-mm)** plastic body, with outlets in quantities and sizes indicated. Include gray-iron frame and slotted grate.
3. PE Systems:
  - a. Channel Sections: Interlocking-joint, PE modular units, **4 inches (102 mm)** wide, with end caps. Include rounded bottom, with level invert and with outlets in quantities, sizes, and locations indicated.
  - b. Grates: PE, ladder shaped; with stainless-steel screws.
  - c. Color: Gray unless otherwise indicated.
  - d. Drainage Specialties: Include the following PE components:
    - 1) Drains: **4-inch- (102-mm-)** diameter, round, slotted top; with **NPS 4 (DN 100)** bottom outlet.  
**OR**  
Drains: **8-inch- (203-mm-)** diameter, round, slotted top; with **NPS 6 (DN 150)** bottom outlet.  
**OR**  
Drains: **4-inch- (102-mm-)** square, slotted top; with **NPS 3 (DN 80)** bottom outlet.  
**OR**  
Drains: **8-inch- (203-mm-)** square, slotted top; with **NPS 6 (DN 150)** bottom outlet.  
**OR**  
Catch Basins: **12-inch- (305-mm-)** square plastic body, with outlets in quantities and sizes indicated. Include PE slotted grate **11-3/4 inches (298 mm)** square by **1-1/8 inches (28.6 mm)** thick.
4. Supports, Anchors, and Setting Devices: Manufacturer's standard unless otherwise indicated.
5. Channel-Section Joining and Fastening Materials: As recommended by system manufacturer.

#### W. Catch Basins

1. Standard Precast Concrete Catch Basins:
  - a. Description: **ASTM C 478 (ASTM C 478M)**, precast, reinforced concrete, of depth indicated, with provision for sealant joints.
  - b. Base Section: **6-inch (150-mm)** minimum thickness for floor slab and **4-inch (102-mm)** minimum thickness for walls and base riser section, and separate base slab or base section with integral floor.
  - c. Riser Sections: **4-inch (102-mm)** minimum thickness, **48-inch (1200-mm)** diameter, and lengths to provide depth indicated.
  - d. Top Section: Eccentric-cone type unless concentric-cone or flat-slab-top type is indicated. Top of cone of size that matches grade rings.
  - e. Joint Sealant: **ASTM C 990 (ASTM C 990M)**, bitumen or butyl rubber.
  - f. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.  
**OR**  
Grade Rings: Include two or three reinforced-concrete rings, of **6- to 9-inch (150- to 225-mm)** total thickness, that match **24-inch- (610-mm-)** diameter frame and grate.

- g. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches (1500 mm).
  - h. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.
  2. Designed Precast Concrete Catch Basins: ASTM C 913, precast, reinforced concrete; designed according to ASTM C 890 for A-16 (ASSHTO HS20-44), heavy-traffic, structural loading; of depth, shape, and dimensions indicated, with provision for joint sealants.
    - a. Joint Sealants: ASTM C 990 (ASTM C 990M), bitumen or butyl rubber.
    - b. Adjusting Rings: Interlocking rings with level or sloped edge in thickness and shape matching catch basin frame and grate. Include sealant recommended by ring manufacturer.

**OR**

Grade Rings: Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 225-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and grate.
  - c. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, 1/2-inch (13-mm) steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at 12- to 16-inch (300- to 400-mm) intervals. Omit steps if total depth from floor of catch basin to finished grade is less than 60 inches (1500 mm).
  - d. Pipe Connectors: ASTM C 923 (ASTM C 923M), resilient, of size required, for each pipe connecting to base section.
  3. Frames and Grates (for rectangular structures): ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include flat grate with small square or short-slotted drainage openings.
    - a. Size: 24 by 24 inches (610 by 610 mm) minimum unless otherwise indicated.
    - b. Grate Free Area: Approximately 50 percent unless otherwise indicated.
  4. Frames and Grates (for round, manhole-type structures): ASTM A 536, Grade 60-40-18, ductile iron designed for A-16, structural loading. Include 24-inch (610-mm) ID by 7- to 9-inch (175- to 225-mm) riser with 4-inch (102-mm) minimum width flange, and 26-inch- (660-mm-) diameter flat grate with small square or short-slotted drainage openings.
    - a. Grate Free Area: Approximately 50 percent unless otherwise indicated.
- X. Stormwater Inlets
1. Curb Inlets: Made with vertical curb opening, of materials and dimensions according to utility standards.
  2. Gutter Inlets: Made with horizontal gutter opening, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.
  3. Combination Inlets: Made with vertical curb and horizontal gutter openings, of materials and dimensions according to utility standards. Include heavy-duty frames and grates.
  4. Frames and Grates: Heavy duty, according to utility standards.
- Y. Stormwater Detention Structures
1. Cast-in-Place Concrete, Stormwater Detention Structures: Constructed of reinforced-concrete bottom, walls, and top; designed according to ASTM C 890 for A-16 (AASHTO HS20-44), heavy-traffic, structural loading; of depth, shape, dimensions, and appurtenances indicated.
    - a. Ballast: Increase thickness of concrete as required to prevent flotation.
    - b. Grade Rings (if required): Include two or three reinforced-concrete rings, of 6- to 9-inch (150- to 229-mm) total thickness, that match 24-inch- (610-mm-) diameter frame and cover.

- c. Steps: Individual FRP steps or FRP ladder **OR** Individual FRP steps; FRP ladder; or ASTM A 615/A 615M, deformed, **1/2-inch (13-mm)** steel reinforcing rods encased in ASTM D 4101, PP **OR** ASTM A 615/A 615M, deformed, **1/2-inch (13-mm)** steel reinforcing rods encased in ASTM D 4101, PP, **as directed**, wide enough to allow worker to place both feet on one step and designed to prevent lateral slippage off step. Cast or anchor steps into sidewalls at **12- to 16-inch (300- to 400-mm)** intervals. Omit steps if total depth from floor of structure to finished grade is less than **60 inches (1500 mm)**.
2. Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, ductile-iron castings designed for heavy-duty service. Include **24-inch (610-mm)** ID by **7- to 9-inch (175- to 225-mm)** riser with **4-inch (102-mm)** minimum width flange, and **26-inch- (660-mm-)** diameter cover. Include indented top design with lettering cast into cover, using wording equivalent to "STORM SEWER."

#### Z. Pipe Outlets

1. Head Walls: Cast-in-place reinforced concrete, with apron and tapered sides.
2. Riprap Basins: Broken, irregularly sized and shaped, graded stone according to NSSGA's "Quarried Stone for Erosion and Sediment Control."
  - a. Average Size: NSSGA No. R-3, screen opening **2 inches (51 mm)**.
  - b. Average Size: NSSGA No. R-4, screen opening **3 inches (76 mm)**.
  - c. Average Size: NSSGA No. R-5, screen opening **5 inches (127 mm)**.
3. Filter Stone: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. FS-2, No. 4 screen opening, average-size graded stone.
4. Energy Dissipaters: According to NSSGA's "Quarried Stone for Erosion and Sediment Control," No. A-1, **3-ton (2721-kg)** average weight armor stone, unless otherwise indicated.

#### AA. Dry Wells

1. Description: ASTM C 913, precast, reinforced, perforated concrete rings. Include the following:
  - a. Floor: Cast-in-place concrete.
  - b. Cover: Liftoff-type concrete cover with cast-in lift rings.
  - c. Wall Thickness: **4 inches (102 mm)** minimum with **1-inch (25-mm)** diameter or **1-by-3-inch- (25-by-76-mm-)** maximum slotted perforations arranged in rows parallel to axis of ring.
    - 1) Total Free Area of Perforations: Approximately 15 percent of ring interior surface.
    - 2) Ring Construction: Designed to be self-aligning.
  - d. Filtering Material: ASTM D 448, Size No. 24, **3/4- to 2-1/2-inch (19- to 63-mm)** washed, crushed stone or gravel.

#### OR

Description: Manufactured PE side panels and top cover that assemble into **50-gal. (190-L)** storage capacity units.

- a. Side Panels: With knockout ports for piping and seepage holes.
- b. Top Cover: With knockout port for drain.
- c. Filter Fabric: As recommended by unit manufacturer.
- d. Filtering Material: ASTM D 448, Size No. 24, **3/4- to 2-1/2-inch (19- to 63-mm)** washed, crushed stone or gravel.

#### OR

Description: Constructed-in-place aggregate type. Include the following:

- a. Lining: Clay or concrete bricks.
- #### OR
- Lining: Concrete blocks or precast concrete rings with notches or weep holes.
  - b. Filtering Material: ASTM D 448, Size No. 24, **3/4- to 2-1/2-inch (19- to 63-mm)** washed, crushed stone or gravel.
  - c. Cover: Precast, reinforced-concrete slab, designed for structural loading according to ASTM C 890 and made according to ASTM C 913. Include slab dimensions that will extend **12 inches (300 mm)** minimum beyond edge of excavation, with bituminous coating over entire surface. Cast cover with opening for manhole in center.
  - d. Manhole: **24-inch- (610-mm-)** diameter, reinforced-concrete access lid with steel lift rings. Include bituminous coating over entire surface.



BB. Stormwater Disposal Systems

1. Chamber Systems:

- a. Storage and Leaching Chambers: Molded PE with perforated sides and open bottom. Include number of chambers, distribution piping, end plates, and other standard components as required for system total capacity.
- b. Filtering Material: ASTM D 448, Size No. 24, 3/4- to 2-1/2-inch (19- to 63-mm) washed, crushed stone or gravel.
- c. Filter Mat: Geotextile woven or spun filter fabric, in one or more layers, for minimum total unit weight of 4 oz./sq. yd. (135 g/sq. m).

OR

Pipe Systems: Perforated manifold, header, and lateral piping complying with AASHTO M 252M for NPS 10 (DN 250) and smaller, AASHTO M 294M for NPS 12 to NPS 60 (DN 300 to DN 1500). Include proprietary fittings, couplings, seals, and filter fabric.

1.3 EXECUTION

1.4 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Division 31 Section "Earth Moving".

B. Piping Installation

1. General Locations and Arrangements: Drawing plans and details indicate general location and arrangement of underground storm drainage piping. Location and arrangement of piping layout take into account design considerations. Install piping as indicated, to extent practical. Where specific installation is not indicated, follow piping manufacturer's written instructions.
2. Install piping beginning at low point, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
3. Install manholes for changes in direction unless fittings are indicated. Use fittings for branch connections unless direct tap into existing sewer is indicated.
4. Install proper size increasers, reducers, and couplings where different sizes or materials of pipes and fittings are connected. Reducing size of piping in direction of flow is prohibited.
5. When installing pipe under streets or other obstructions that cannot be disturbed, use pipe-jacking process of microtunneling.
6. Install gravity-flow, nonpressure drainage piping according to the following:
  - a. Install piping pitched down in direction of flow.
  - b. Install piping NPS 6 (DN 150) and larger with restrained joints at tee fittings and at changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
  - c. Install piping with 36-inch (915-mm) OR 48-inch (1220-mm) OR 60-inch (1520-mm) OR 72-inch (1830-mm), as directed, minimum cover.
  - d. Install hub-and-spigot, cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
  - e. Install hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook."
  - f. Install ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
  - g. Install corrugated steel piping according to ASTM A 798/A 798M.
  - h. Install corrugated aluminum piping according to ASTM B 788/B 788M.
  - i. Install ABS sewer piping according to ASTM D 2321 and ASTM F 1668.
  - j. Install PE corrugated sewer piping according to ASTM D 2321.
  - k. Install PVC cellular-core piping according to ASTM D 2321 and ASTM F 1668.
  - l. Install PVC sewer piping according to ASTM D 2321 and ASTM F 1668.
  - m. Install PVC profile gravity sewer piping according to ASTM D 2321 and ASTM F 1668.

- n. Install PVC water-service piping according to ASTM D 2321 and ASTM F 1668.
- o. Install fiberglass sewer piping according to ASTM D 3839 and ASTM F 1668.
- p. Install nonreinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
- q. Install reinforced-concrete sewer piping according to ASTM C 1479 and ACPA's "Concrete Pipe Installation Manual."
- 7. Install force-main pressure piping according to the following:
  - a. Install piping with restrained joints at tee fittings and at horizontal and vertical changes in direction. Use corrosion-resistant rods, pipe or fitting manufacturer's proprietary restraint system, or cast-in-place concrete supports or anchors.
  - b. Install piping with **36-inch (915-mm) OR 48-inch (1220-mm) OR 60-inch (1520-mm) OR 72-inch (1830-mm)**, **as directed**, minimum cover.
  - c. Install **ductile**-iron pressure piping according to AWWA C600 or AWWA M41.
  - d. Install ductile-iron special fittings according to AWWA C600.
  - e. Install PVC pressure piping according to AWWA M23, or ASTM D 2774 and ASTM F 1668.
  - f. Install PVC water-service piping according to ASTM D 2774 and ASTM F 1668.
- 8. Install corrosion-protection piping encasement over the following underground metal piping according to ASTM A 674 or AWWA C105:
  - a. Hub-and-spigot, cast-iron soil pipe and fittings.
  - b. Hubless cast-iron soil pipe and fittings.
  - c. Ductile-iron pipe and fittings.
  - d. Expansion joints and deflection fittings.

#### C. Pipe Joint Construction

- 1. Join gravity-flow, nonpressure drainage piping according to the following:
  - a. Join hub-and-spigot, cast-iron soil piping with gasketed joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
  - b. Join hub-and-spigot, cast-iron soil piping with calked joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for lead and oakum calked joints.
  - c. Join hubless cast-iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
  - d. Join ductile-iron culvert piping according to AWWA C600 for push-on joints.
  - e. Join ductile-iron piping and special fittings according to AWWA C600 or AWWA M41.
  - f. Join corrugated steel sewer piping according to ASTM A 798/A 798M.
  - g. Join corrugated aluminum sewer piping according to ASTM B 788/B 788M.
  - h. Join ABS sewer piping according to ASTM D 2321 and ASTM D 2751 for elastomeric-seal joints.
  - i. Join corrugated PE piping according to ASTM D 3212 for push-on joints.
  - j. Join PVC cellular-core piping according to ASTM D 2321 and ASTM F 891 for solvent-cemented joints.
  - k. Join PVC corrugated sewer piping according to ASTM D 2321 for elastomeric-seal joints.
  - l. Join PVC sewer piping according to ASTM D 2321 and ASTM D 3034 for elastomeric-seal joints or ASTM D 3034 for elastomeric-gasketed joints.
  - m. Join PVC profile gravity sewer piping according to ASTM D 2321 for elastomeric-seal joints or ASTM F 794 for gasketed joints.
  - n. Join fiberglass sewer piping according to ASTM D 3839 for elastomeric-seal joints.
  - o. Join nonreinforced-concrete sewer piping according to **ASTM C 14 (ASTM C 14M)** and ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
  - p. Join reinforced-concrete sewer piping according to ACPA's "Concrete Pipe Installation Manual" for rubber-gasketed joints.
  - q. Join dissimilar pipe materials with nonpressure-type flexible couplings.
- 2. Join force-main pressure piping according to the following:
  - a. Join ductile-iron pressure piping according to AWWA C600 or AWWA M41 for push-on joints.

- b. Join ductile-iron special fittings according to AWWA C600 or AWWA M41 for push-on joints.
  - c. Join PVC pressure piping according to AWWA M23 for gasketed joints.
  - d. Join PVC water-service piping according to ASTM D 2855 for solvent-cemented joints.
  - e. Join dissimilar pipe materials with pressure-type couplings.
- D. Backwater Valve Installation
  1. Install horizontal-type backwater valves in piping where indicated.
  2. Install combination horizontal and manual gate-valve type in piping and in manholes where indicated.
  3. Install terminal-type backwater valves on end of piping and in manholes where indicated.
- E. Cleanout Installation
  1. Install cleanouts and riser extensions from sewer pipes to cleanouts at grade. Use cast-iron soil pipe fittings in sewer pipes at branches for cleanouts and cast-iron soil pipe for riser extensions to cleanouts. Install piping so cleanouts open in direction of flow in sewer pipe.
    - a. Use Light-Duty, top-loading classification cleanouts in earth or unpaved foot-traffic areas.
    - b. Use Medium-Duty, top-loading classification cleanouts in paved foot-traffic areas.
    - c. Use Heavy-Duty, top-loading classification cleanouts in vehicle-traffic service areas.
    - d. Use Extra-Heavy-Duty, top-loading classification cleanouts in roads.
    - e. Set cleanout frames and covers in earth in cast-in-place concrete block, 18 by 18 by 12 inches (450 by 450 by 300 mm) deep. Set with tops 1 inch (25 mm) above surrounding earth grade.
    - f. Set cleanout frames and covers in concrete pavement and roads with tops flush with pavement surface.
- F. Drain Installation
  1. Install type of drains in locations indicated.
    - a. Use Light-Duty, top-loading classification drains in earth or unpaved foot-traffic areas.
    - b. Use Medium-Duty, top-loading classification drains in paved foot-traffic areas.
    - c. Use Heavy-Duty, top-loading classification drains in vehicle-traffic service areas.
    - d. Use Extra-Heavy-Duty, top-loading classification drains in roads.
  2. Embed drains in 4-inch (102-mm) minimum concrete around bottom and sides.
  3. Fasten grates to drains if indicated.
  4. Set drain frames and covers with tops flush with pavement surface.
  5. Assemble trench sections with flanged joints.
  6. Embed trench sections in 4-inch (102-mm) minimum concrete around bottom and sides.
- G. Manhole Installation
  1. General: Install manholes, complete with appurtenances and accessories indicated.
  2. Install precast concrete manhole sections with sealants according to ASTM C 891.
  3. Where specific manhole construction is not indicated, follow manhole manufacturer's written instructions.
  4. Set tops of frames and covers flush with finished surface of manholes that occur in pavements. Set tops 3 inches (76 mm) above finished surface elsewhere unless otherwise indicated.
- H. Catch Basin Installation
  1. Construct catch basins to sizes and shapes indicated.
  2. Set frames and grates to elevations indicated.
- I. Stormwater Inlet And Outlet Installation
  1. Construct inlet head walls, aprons, and sides of reinforced concrete, as indicated.
  2. Construct riprap of broken stone, as indicated.
  3. Install outlets that spill onto grade, anchored with concrete, where indicated.
  4. Install outlets that spill onto grade, with flared end sections that match pipe, where indicated.
  5. Construct energy dissipaters at outlets, as indicated.



**J. Dry Well Installation**

1. Excavate hole to diameter of at least **6 inches (150 mm)** greater than outside of dry well. Do not extend excavation into ground-water table.
2. Install precast, concrete-ring dry wells according to the following:
  - a. Assemble rings to depth indicated.
  - b. Extend rings to height where top of cover will be approximately **8 inches (203 mm)** below finished grade.
  - c. Backfill bottom of inside of rings with filtering material to level at least **12 inches (300 mm)** above bottom.
  - d. Extend effluent inlet pipe **12 inches (300 mm)** into rings and terminate into side of tee fitting.
  - e. Backfill around outside of rings with filtering material to top level of rings.
  - f. Install cover over top of rings.
3. Install manufactured, PE dry wells according to manufacturer's written instructions and the following:
  - a. Assemble and install panels and cover.
  - b. Backfill bottom of inside of unit with filtering material to level at least **12 inches (300 mm)** above bottom.
  - c. Extend effluent inlet pipe **12 inches (300 mm)** into unit and terminate into side of tee fitting.
  - d. Install filter fabric around outside of unit.
  - e. Install filtering material around outside of unit.
4. Install constructed-in-place dry wells according to the following:
  - a. Install brick lining material dry and laid flat, with staggered joints for seepage. Build to diameter and depth indicated.
  - b. Install block lining material dry, with staggered joints and 20 percent minimum of blocks on side for seepage. Install precast concrete rings with notches or weep holes for seepage. Build to diameter and depth indicated.
  - c. Extend lining material to height where top of manhole will be approximately **8 inches (203 mm)** below finished grade.
  - d. Backfill bottom of inside of lining with filtering material to level at least **12 inches (300 mm)** above bottom.
  - e. Extend effluent inlet pipe **12 inches (300 mm)** into lining and terminate into side of tee fitting.
  - f. Backfill around outside of lining with filtering material to top level of lining.
  - g. Install manhole over top of dry well. Support cover on undisturbed soil. Do not support cover on lining.

**K. Concrete Placement**

1. Place cast-in-place concrete according to ACI 318.

**L. Channel Drainage System Installation**

1. Install with top surfaces of components, except piping, flush with finished surface.
2. Assemble channel sections to form slope down toward drain outlets. Use sealants, adhesives, fasteners, and other materials recommended by system manufacturer.
3. Embed channel sections and drainage specialties in **4-inch (102-mm)** minimum concrete around bottom and sides.
4. Fasten grates to channel sections if indicated.
5. Assemble channel sections with flanged or interlocking joints.
6. Embed channel sections in **4-inch (102-mm)** minimum concrete around bottom and sides.

**M. Stormwater Disposal System Installation**

1. Chamber Systems: Excavate trenches of width and depth, and install system and backfill according to chamber manufacturer's written instructions. Include storage and leaching chambers, filtering material, and filter mat.

**OR**

Piping Systems: Excavate trenches of width and depth, and install piping system, filter fabric, and backfill, according to piping manufacturer's written instructions.

N. Connections

1. Connect nonpressure, gravity-flow drainage piping in building's storm building drains specified in Division 22 Section "Facility Storm Drainage Piping".
2. Connect force-main piping to building's storm drainage force mains specified in Division 22 Section "Facility Storm Drainage Piping". Terminate piping where indicated.
3. Make connections to existing piping and underground manholes.
  - a. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus **6-inch (150-mm)** overlap, with not less than **6 inches (150 mm)** of concrete with 28-day compressive strength of **3000 psi (20.7 MPa)**.
  - b. Make branch connections from side into existing piping, **NPS 4 to NPS 20 (DN 100 to DN 500)**. Remove section of existing pipe, install wye fitting into existing piping, and encase entire wye with not less than **6 inches (150 mm)** of concrete with 28-day compressive strength of **3000 psi (20.7 MPa)**.
  - c. Make branch connections from side into existing piping, **NPS 21 (DN 525)** or larger, or to underground manholes and structures by cutting into existing unit and creating an opening large enough to allow **3 inches (76 mm)** of concrete to be packed around entering connection. Cut end of connection pipe passing through pipe or structure wall to conform to shape of and be flush with inside wall unless otherwise indicated. On outside of pipe, manhole, or structure wall, encase entering connection in **6 inches (150 mm)** of concrete for minimum length of **12 inches (300 mm)** to provide additional support of collar from connection to undisturbed ground.
    - 1) Use concrete that will attain a minimum 28-day compressive strength of **3000 psi (20.7 MPa)** unless otherwise indicated.
    - 2) Use epoxy-bonding compound as interface between new and existing concrete and piping materials.
  - d. Protect existing piping, manholes, and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.
4. Connect to sediment interceptors specified in Division 22 Section "Sanitary Waste Interceptors".
5. Pipe couplings, expansion joints, and deflection fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
  - a. Use nonpressure-type flexible couplings where required to join gravity-flow, nonpressure sewer piping unless otherwise indicated.
    - 1) Unshielded **OR** Shielded, **as directed**, flexible couplings for same or minor difference OD pipes.
    - 2) Unshielded, increaser/reducer-pattern, flexible couplings for pipes with different OD.
    - 3) Ring-type flexible couplings for piping of different sizes where annular space between smaller piping's OD and larger piping's ID permits installation.
  - b. Use pressure-type pipe couplings for force-main joints.

O. Closing Abandoned Storm Drainage Systems

1. Abandoned Piping: Close open ends of abandoned underground piping indicated to remain in place. Include closures strong enough to withstand hydrostatic and earth pressures that may result after ends of abandoned piping have been closed. Use either procedure below:
  - a. Close open ends of piping with at least **8-inch- (203-mm-)** thick, brick masonry bulkheads.
  - b. Close open ends of piping with threaded metal caps, plastic plugs, or other acceptable methods suitable for size and type of material being closed. Do not use wood plugs.
2. Abandoned Manholes and Structures: Excavate around manholes and structures as required and use one procedure below:
  - a. Remove manhole or structure and close open ends of remaining piping.

- b. Remove top of manhole or structure down to at least **36 inches (915 mm)** below final grade. Fill to within **12 inches (300 mm)** of top with stone, rubble, gravel, or compacted dirt. Fill to top with concrete.
- 3. Backfill to grade according to Division 31 Section "Earth Moving".

P. Identification

- 1. Materials and their installation are specified in Division 31 Section "Earth Moving". Arrange for installation of green warning tape directly over piping and at outside edge of underground structures.
  - a. Use warning tape **OR** detectable warning tape, **as directed**, over ferrous piping.
  - b. Use detectable warning tape over nonferrous piping and over edges of underground structures.

Q. Field Quality Control

- 1. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately **24 inches (610 mm)** of backfill is in place, and again at completion of Project.
  - a. Submit separate reports for each system inspection.
  - b. Defects requiring correction include the following:
    - 1) Alignment: Less than full diameter of inside of pipe is visible between structures.
    - 2) Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    - 3) Damage: Crushed, broken, cracked, or otherwise damaged piping.
    - 4) Infiltration: Water leakage into piping.
    - 5) Exfiltration: Water leakage from or around piping.
  - c. Replace defective piping using new materials, and repeat inspections until defects are within allowances specified.
  - d. Reinspect and repeat procedure until results are satisfactory.
- 2. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
  - a. Do not enclose, cover, or put into service before inspection and approval.
  - b. Test completed piping systems according to requirements of authorities having jurisdiction.
  - c. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
  - d. Submit separate report for each test.
  - e. Gravity-Flow Storm Drainage Piping: Test according to requirements of authorities having jurisdiction, UNI-B-6, and the following:
    - 1) Exception: Piping with soiltight joints unless required by authorities having jurisdiction.
    - 2) Option: Test plastic piping according to ASTM F 1417.
    - 3) Option: Test concrete piping according to **ASTM C 924 (ASTM C 924M)**.
  - f. Force-Main Storm Drainage Piping: Perform hydrostatic test after thrust blocks, supports, and anchors have hardened. Test at pressure not less than 1-1/2 times the maximum system operating pressure, but not less than **150 psig (1035 kPa)**.
    - 1) Ductile-Iron Piping: Test according to AWWA C600, "Hydraulic Testing" Section.
    - 2) PVC Piping: Test according to AWWA M23, "Testing and Maintenance" Chapter.
- 3. Leaks and loss in test pressure constitute defects that must be repaired.
- 4. Replace leaking piping using new materials, and repeat testing until leakage is within allowances specified.

R. Cleaning

- 1. Clean interior of piping of dirt and superfluous materials. Flush with potable water **OR** Flush with water, **as directed**.



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Task	Specification	Specification Description
33 42 11 00	21 05 23 00	Piped Utilities Basic Materials And Methods
33 42 11 00	33 14 13 23	Sand Drains
33 42 11 00	13 12 13 00	Water Distribution
33 42 11 00	22 05 76 00	Sanitary Sewerage
33 42 11 00	33 14 13 23b	Ground-Loop Heat-Pump Piping
33 42 11 00	31 05 13 00	Subdrainage
33 42 11 00	22 11 16 00b	Storm Drainage Piping
33 42 11 00	22 05 76 00a	Storm Drainage Piping Specialties

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